THE ENGINEER.

The Machine Tool Exhibition at Olympia.

The Machine Tool and Engineering Exhibition.

SINCE 1928 engineers of this country and from abroad have been unable to survey, generally, the progress made in the interval by British machine tool manufacturers. But with the opening yesterday at Olympia of the fifth Machine Tool and Engineering Exhibition, organised by the Machine Tool Trades' Association, the opportunity is at last available, and we give in the following pages of this Supplement descriptions of the exhibits of a few of the great number of manufacturers who have taken space at Olympia. Our description of the exhibits, which are international in character and are drawn from many countries in both Europe and America, will be continued in a second Supplement and in the pages of this and following issues.

There have been many developments since the last Exhibition of this kind was held, so that, although it may be regretted that the interval has been so long, solace is provided by the greater resulting interest of the machines to be seen on the stands. The development of new alloy cutting steels and tools of the tungsten carbide variety has had definite repercussions on design. Rigidity has become of great importance in connection with the use of the latter class of tool and higher machining speeds have been made possible. Visitors to the show are likely to be impressed, too, by the popularity of the individual motor drive, which, having driven line shafting from the heavy machine shop, is now invading the medium and even the light machining bays. It is applied not only to individual machines, but also to each separate motion of the machine, and has only been made possible by the researches of electrical engineers. Multi-speed motors and reversing motors are, too, beginning to take the place of mechanical gearing in some applications. These two changes indicate the most obviously visible signs of progress, but they are by no means the only ones. Ball and roller bearings of various types are achieving a greater popularity on account of the ease with which they can be grease lubricated by "one-shot" methods, and the manner in which they can reduce friction losses amongst the many shafts of a modern machine. Considerable attention has been directed towards the further development of automatic machines, which formerly appealed more particularly to the motor car industry, but which seem now to be coming into wider favour.

This introductory survey could be extended to cover many other fields. The development in grinding machinery, for instance, has not been mentioned, nor the changes and improvements that are taking place in heat treatment processes; nor the application of hydraulic power to various motions. But we believe that the pages of this Supplement and that which will be published with the following issue of THE ENGINEER, together with the articles in the body of the paper itself, will sufficiently indicate how great the progress has been and in what direction it is tending to take place.

CRAVEN BROTHERS (MANCHESTER), LTD.

The firm of Craven Brothers (Manchester), Ltd., Reddish, Stockport, has a very large display of its manufactures distributed over three stands, and comprising lathes, grinding machines, slotting machines, and milling machines.

The lathe illustrated in Fig. 1, which weighs complete about 39 tons, is intended for the turning of tin-plate rolls up to 45in. body diameter and 16ft. in overall length. Its principal dimensions are given in the following table :—

Height of centres	30½in.
Maximum swing over saddles	45in.
Admits between centres	16ft.
Width of slide bed	6ft. 6in.
Diameter and length of front neck of spindle in driving headstock	12in. dia. × 18in. long
Main motor	35 H.P.
Saddle traverse motors (two required)	1½ H.P.
Pump motor	¾ H.P.
Approximate net weight, exclusive of electrical equipment	39 tons

The roll to be turned is held by both wobbler ends in powerful chucks, and both the roll body and the journals may be turned between chucking, supported by the main headstock spindle at one end and the revolving tailstock spindle at the other. Tungsten carbide tools may be used—indeed, the machine is specially designed for their use—and a screw motion, as opposed to hammer and wedge, is utilised for their adjustment and in-feed. As may be seen from the engraving, the bed is of the three shear type, on the two front shears of which the front saddles rest, while the middle and back shears support the tailstock and rear saddle. Internal lighting is fitted to the totally enclosed headstock, which has large inspection windows. Auxiliary shafts run in roller and ball journal bearings, but the high carbon steel spindle is carried by phosphor-bronze bearings. In full view of the operator there are two dials showing the speed of revolution and the ampères absorbed. The left-hand saddle takes a cambering motion from a cam and compound levers, and variation in the lengths of rolls is provided for by change wheels. On the right-hand saddle there is a parting tool holder for cutting off risers or wobbler extensions. The reversible feed traverse and the hand adjustment saddle feeds are obtained from a variable ratchet traverse on a multi-thread screw. Longitudinal feeds at eight rates from $\frac{1}{32}$in. to $\frac{1}{4}$in. inclusive, are available, and both front saddles have also eight rates of cross feed from $^1/_{48}$in. to $\frac{1}{8}$in. per revolution of the work. Longitudinal quick power traverse is fitted to the front saddles. Although the rear saddle can be adjusted longitudinally only by hand it is capable of the same automatic in-feeds as the front saddles, and is thus suitable for any in-feed work or for parting rolls for breaking. The spindle of the tailstock runs in double roller bearings at its forward end and double ball bearings at the rear. Visitors to the stand should note that the machine is raised 12in. above the floor owing to the necessity of accommodating electric collecting wires which would normally be placed in a trench under the foundation.

The machine illustrated in Fig. 2 is, as it were, a companion to that just described. It is capable of grinding rolls for the tin-plate trade up to 40in. in diameter with a 20in. wheel, or up to 34in. diameter with a 26in. wheel. The width of the wheel is 2½in. and the maximum length of roll admitted 10ft. and ground 7ft. The machine exhibited may be used for grinding new rolls or for re-surfacing used rolls, and if the special chamfer grinding rest is fitted a roll can be completely finished at one setting. The operator's seat is placed near the grinding wheel so that he has a clear and uninterrupted view, and by means of grouped controls and automatic reversing saddle traverse he is enabled to devote the whole of his attention to the actual grinding of the roll. A special cambering unit is fitted to the machine, and either concave, convex, or parallel rolls may be produced as desired. The grinding saddle bed has one vee-way and one flat-way, and a rack for traversing the grinding saddle is fixed between the bed ways and protected throughout its length by a steel guard. A rack for rotating the cambering cam and a longitudinal slot to take the adjustable reversing dogs for reversing the saddle traverse are situated at the front of the bed. The work bed has two flat ways to which the roll revolving headstock, loose headstock, and roll supports are fitted. Hand motion to roll heads, stays, and the chamfer grinding attachment, is obtained from a rack fitted to the back of the bed. Lubrication of the grinding saddle bed ways is effected from a pressure oiling system mounted on the saddle and operated by a conveniently placed foot lever. The saddle has power traverse in both directions. The traverse is driven by a 4½ H.P. motor mounted on the

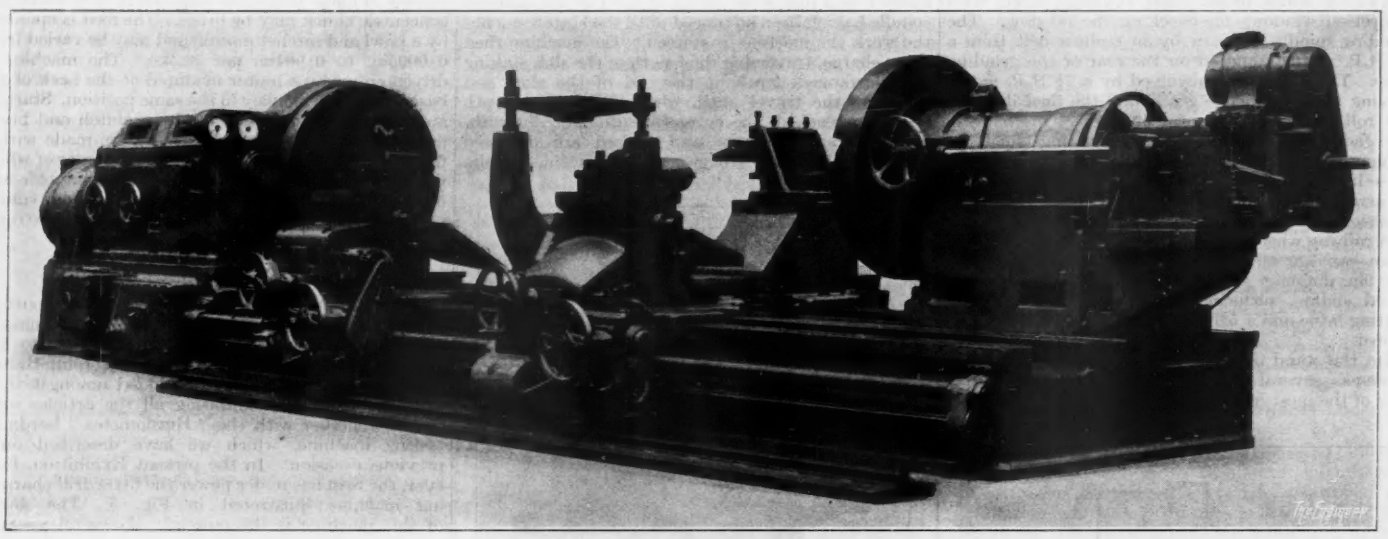


FIG. 1—LARGE TIN-PLATE ROLL TURNING LATHE—CRAVEN

saddle, which drives a rack pinion through a worm reduction gear and an eight-speed change gear-box. All gears are totally enclosed and positively lubricated. All controls for the saddle, both self-acting and hand, are grouped so that the operator may reach any one without changing his position. Trip levers positioned in the bed engage a lever on the traverse box for the reverse traverse, which may also be operated by hand at any desired position on the bed. The grinding head consists of a transverse slide with fine and coarse hand adjustment for the grinding wheel feed, mounted on an intermediate slide, fitted with trunnion type bearings on the saddle, and carrying the grinding spindle, which runs in automatically lubricated white metal lined bearings fitted with inspection windows for checking the oil flow. The grinding spindle is driven by an endless belt from a 20 H.P. motor mounted on the rear of the grinding slide. The roll head is revolved by a 7½ H.P. motor driving through change gears, and the final drive to the roll is through a worm and wheel mechanism. The face-plate, carrying a special floating chuck for driving the roll, revolves round a dead centre. The loose headstock also is fitted with a dead centre and is arranged with a set-over apparatus to adjust to absolute parallelism or to the desired conicity.

A railway wheel lathe for turning new or re-turning worn carriage and wagon wheels from 2ft. 9in. to 3ft. 9in. diameter; a 24in. centre heavy duty high-speed sliding, surfacing, taper turning and screw-cutting lathe and a 52in. vertical turret lathe are also shown.

On the stand of A. C. Wickman, Ltd., agents for Cravens, several smaller machines are exhibited. One of the most interesting of this group of machines

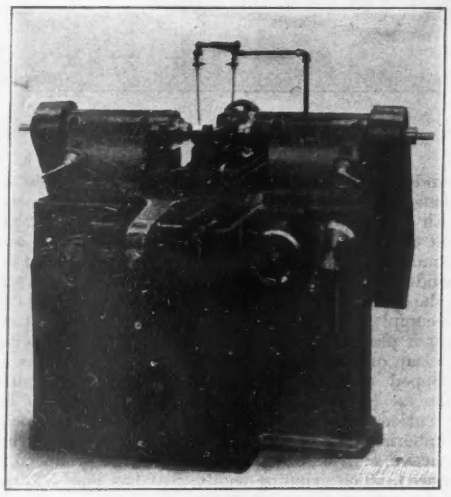


FIG. 3—SLOT-HYDROMIL—CRAVEN

is the "Slot-Hydromil," illustrated in Fig. 3. Slot milling is a milling operation in which an end mill is used to mill out a slot by many repeated quick traverses over a fixed distance, sinking only a few thousandths at each passage. By this method accurate internal milling may be done on delicate finished pieces without damaging the work by the powerful clamping which is necessary in ordinary milling. The machine is designed to mill two slots simultaneously by means of two horizontal spindles. These slots may be both in one shaft or one in each of two shafts, or may be the two halves of one slot which extends entirely through the shaft, *i.e.*, a cotterway. Many kinds of workpieces other than shafts may be operated on, as slotted links, gun and small arms parts, valve slots, or any delicate mortising or facing operation on metal, ebonite, fibre, or the like.

The machine has a table travel of 12in. and in-feed of each of the two spindles of 1¼in. It will take cutters up to 1in. diameter and will cut keyways in steel up to 12in. long by 1in. wide by 1¼in. deep on work-pieces up to 6in. in diameter. Cotterways the same length and depth can be cut in diameters up to 3in. The machine works automatically. Stop dogs are adjusted to allow the table to travel the length of the desired slot less the diameter of the cutter. A micrometer depth dial is set to the desired depth, and the spindle having been advanced until the cutter touches the work the machine is started. The machine then takes charge, traversing the length of the slot, sinking a pre-arranged depth at the end of the slot, and reversing the travel until, when the desired depth has been reached, the cutter is automatically withdrawn. Both traverse and in-feed are operated hydraulically. Any traverse rate from 1in. to 48in.

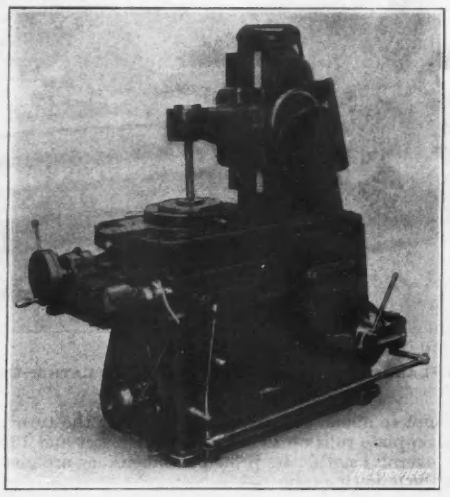


FIG. 4—SPLINE SLOTTING MACHINE—CRAVEN

per minute is available, and in practice 24in. per minute has been found suitable for most work. The in-feed is regulated by a dial graduated in thousandths of an inch, and any rate from 1 to 20 thousandths can be obtained and is put into effect at the end of each traverse. The hydraulic unit is housed in the cabinet base of the machine and communicates by copper pipes with a small cylinder placed underneath the table. Power is obtained from a simple gear pump driven from the pulley shaft and having a relief valve. The inlet and exhaust oil circuits pass through two openings in a sliding piston valve which controls the direction of flow. A rack on the reversing valve rocks a cam shaft actuating the in-feed during the short dwell at each end of the traverse. Nine changes of spindle speed from 356 to 1834 r.p.m. are obtainable from a dial change gear box.

Several "Craven Rigid" milling machines are shown on the Wickman stand, together with an automobile crank shaft turning machine of considerable interest. But perhaps the automatic spline slotting machine, illustrated in Fig. 4, will prove a greater attraction. This tool has been designed for slotting the splines in the bores of gear wheel blanks and components of a similar nature. The splines are cut one at a time by a tool carried in a vertical slotting bar supported both above and below the work. A reciprocating motion is imparted to the bar and the tool is automatically relieved on the upward non-cutting stroke. Normally the work is indexed by hand, but the feed is automatically tripped when the correct spline depth has been reached. The table is supported on a double vee track and is provided with a hardened index plate, usually arranged to give two, three, four, six, or eight splines. A register is machined on the table for centralising purposes. In the case of repetition work the register carries an adapter plate to receive the blanks, but for use on a variety of blank diameters a special form of three-jaw concentric chuck may be fitted. The feed is operated by a pawl and ratchet motion and may be varied from 0·0005in. to 0·004in. per stroke. The machine is driven either by a motor mounted at the back of the base or through a pulley in the same position. Starting and stopping is provided for by a clutch and brake mechanism. Two sizes of machine are made with a 6in. and a 9in. stroke respectively, the larger of which will take work up to 18in. outside diameter and 5in. bore and down to 1¼in. bore. It will cut splines up to 1½in. wide at thirty, forty-five, or sixty strokes per minute and absorbs 4½ H.P.

THOS. FIRTH AND JOHN BROWN.

The exhibits of firms which make such important things as cutters, reamers, saws, lathe tools, chisels, drills, rasps, and files are seldom amenable to any lengthy description. Thos. Firth and John Brown, Ltd., of Sheffield, must be included amongst those firms, for they are exhibiting all the articles mentioned, together with the "Hardometer" hardness-testing machine, which we have described on a previous occasion. In the present Exhibition, however, the firm has under power the little drill-sharpening machine illustrated in Fig. 5. The design of this machine is the outcome of several years of

FIG. 5—DRILL-SHARPENER—FIRTH

development work, and it was built primarily to meet the firm's own requirements as a manufacturer of twist drills. Its main features will be seen from the engraving. It will take drills from $\frac{1}{16}$in. to ½in. diameter, and can be supplied either for mounting on the bench or suitably supported on standards. Countershaft or direct motor drive may be adopted, and the engraving shows the latter type, the motor itself being hidden in the view. The machine has a wheel 6in. diameter by ⅛in. wide, and the power required is ¼ H.P. We need not refer to all the details of the design, but it may be noted that there is a

diamond holder for dressing the wheel, and that in operation the wheel is given a positively driven oscillating motion to prevent grooving. The work holder can be adjusted to grind points from 180 deg. to 60 deg. included angle, and adjustments are provided for varying the amount of relief or clearance behind the cutting edge. At the rear of the wheel guard there is an outlet to which the usual suction ducting can be connected. On the machine table a complete set of bushes for all the sizes of drills within the range of the machine are set out. Production times obtained with this machine in the makers' shops are 160 per hour for ¼in. diameter, and 125 per hour for ½in. diameter drills.

B. and S. Massey, Ltd.

One of the exhibits on the stand taken by B. and S. Massey, Ltd., of Openshaw, Manchester, which visitors to the show will find particularly interesting, is a portable planing machine for trueing up in position the faces of anvil blocks and the tups of hammers and stamps. This device is illustrated in Fig. 7. It consists of a main "bridge" along which a slide carrying a tool rest runs, and it is driven by belt from any convenient line shaft or motor through pulleys 12in. diameter. With a pulley speed of 480 r.p.m., the cutting speed is 30ft. per minute, and for the expenditure of 3 to 5 B.H.P. cuts ⅜in. deep with a $\frac{1}{32}$in. feed can be taken. The machine is intended primarily for use with drop stamps ranging from 5 cwt. to 35 cwt. It has a stroke of 38in., and will plane a surface 26in. wide. The tool-box is arranged to swivel into any desired position, and has a vertical motion of 5in. Feeds, both vertical and horizontal, are by hand. The

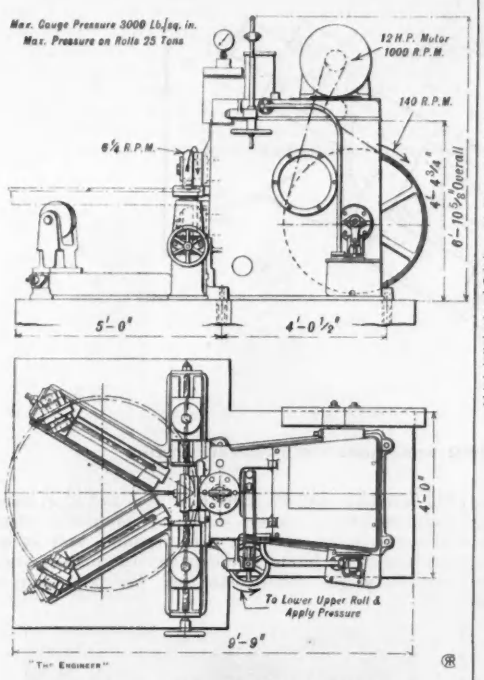


FIG. 6—TIRE-FIXING ROLL—MASSEY

illustration shows the machine planing the anvil block of a pneumatic power hammer. By means of the specially arranged projection on the top of the "bridge" it is securely keyed into the dovetail of the tup. The tup itself, of course, is held firmly in position by tightening the guide bars of the hammer by means of the screw adjustment ordinarily provided. Movement of the machine along the dovetail is prevented by a wedge, and it is steadied in position by four adjustable pillars, two of which can be seen in the illustration. The makers state that after the anvil block has been cleared of poppets, &c., the time required to fix the planing machine in position need not exceed half an hour. By turning the "bridge" the other way up and holding it in the anvil block, the face of the tup can be machined.

Turning away from this little machine attention may be directed to the tire-fixing roll illustrated in the line engraving, Fig. 6. This machine is designed for securing the retaining rings of railway locomotive, carriage, and wagon wheels, and is made in two sizes, one of which will take wheels in diameters between 18in. and 4ft. 6in., and the other between 18in. and 7ft. 6in. The maximum pressure exerted is 25 tons and the rolling speed 18ft. per minute in both machines. One of the advantages claimed for the rolling process of securing retaining rings is that in the case especially of high tensile steel tires, it is "kinder" than hammering, and there can be little doubt that the process is quieter. The upper operating roll, which closes down the lip of the tire, is keyed to a shaft, provided with a worm wheel and carried in a counterbalanced cast iron cradle pivoted about the worm shaft. The lower operating roll is mounted on, but not keyed to, its shaft, which is driven from the upper roll shaft through steel gearing. All shafts and gears are enclosed in the main casting. The tire rests on the lower roll and on two supporting rollers adjustable along the arms of the machine, and is positioned by two guide rollers which are adjusted by a single hand wheel.

Between and behind the operating rolls a small thrust roller helps to take the thrust due to rolling, and also acts as a locating stop when setting. A pump driven from the worm shaft delivers the oil, which is employed as the pressure medium, to the press and to an upper reservoir, the overflow from which lubricates bearings and gears. A small movement of the single hand wheel which controls the oil pressure causes the upper roll to move down on to the tire, and further movement causes pressure

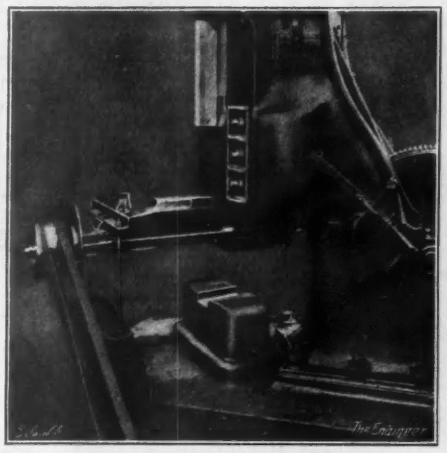


FIG. 7—PORTABLE PLANING MACHINE—MASSEY

to be applied to the extent desired. Movement of the hand wheel in the opposite direction relieves the pressure and the roll rises. The machine can be driven by belt either from a line shaft, in which case fast and loose pulleys are provided, or from an electric motor.

Last, but by no means least, the hammers and presses for which the firm is so well known should be examined. We cannot mention all these machines, but have chosen for illustration in Fig. 8 a 200-ton tie-bolt type trimming press. The main frame pieces, which are constructed of a tough cast iron, are held together by four large steel bolts shrunk in position. The crank shaft is a steel forging, and it runs in replaceable cast iron bearings, carried in the

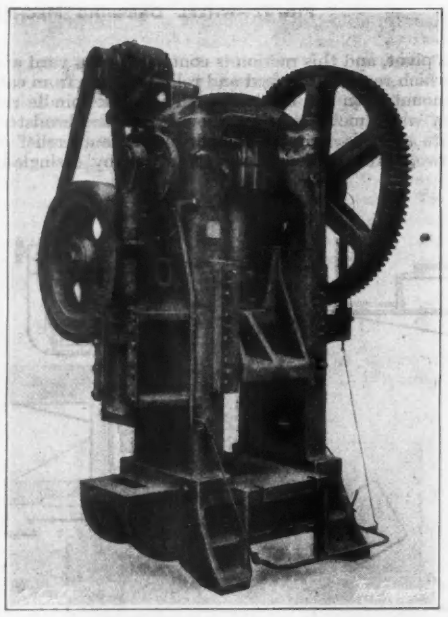


FIG. 8—200-TON TRIMMING PRESS—MASSEY

crown block and by bearing caps supported from the uprights. This design allows the crank shaft to be withdrawn without disturbing the crown block. The particular machine illustrated is driven by an electric motor mounted on the top of the crown block through a wide belt to the fly-wheel on the back shaft. Thence, the power is transmitted through a steel pinion to the main gear wheel on the crank shaft. In order that the stroke of the ram—the strong design of which can be observed in the engraving—shall be adjustable to suit different designs of tools, a screwed connecting-rod joins it to the crank. The machine is controlled through a clutch mechanism actuated by the foot lever to be seen in the engraving. As usual, a brake is so arranged that when the lever is released the ram stops at the top of its stroke. Side shears are situated on the outside of one of the uprights and actuated from a separate excentric.

Lucas Furnaces, Ltd.

Heat treatment furnaces are being exhibited by Lucas Furnaces, Ltd., of Mount Works, Wharton-street, Nechells, Birmingham. The "A" type of furnace, shown in Fig. 9, has been built for practically every kind of heat treatment. It is made in various sizes for operation with natural or forced draught, and with town or power gas. It embodies an efficient metal recuperator, effective insulation, and positive gas screens at the front of the chamber. Uniformity of temperature, correct atmospheric conditions, and a low cost of working are the maker's outstanding claims. The patented tubular casing allows for expansion without distortion, and is claimed to be practically unbreakable. The smallest furnace is 6in. wide by 9in. deep, and the largest so far made is 4ft. wide and 20ft. long. The work is placed on trays, which are pushed into the furnace, which is adapted for annealing light castings, forgings, and for continuous carburising reheating, &c. The maker's "B" type high-speed steel hardening furnace, in which radiated heat transmission without direct contact with the flame or gases of combustion is employed, is claimed to provide the best means of obtaining uniform clean work free from scale or other defects. The muffle is built of fused alumina or silica carbide, and the recuperator is of nickel-chrome alloy. The single-chambered type with a separate preheating furnace is frequently preferred, but the two furnaces can be built into one casing side by side or one over the other. In both cases the furnaces are separately controlled, and can be used independently. The

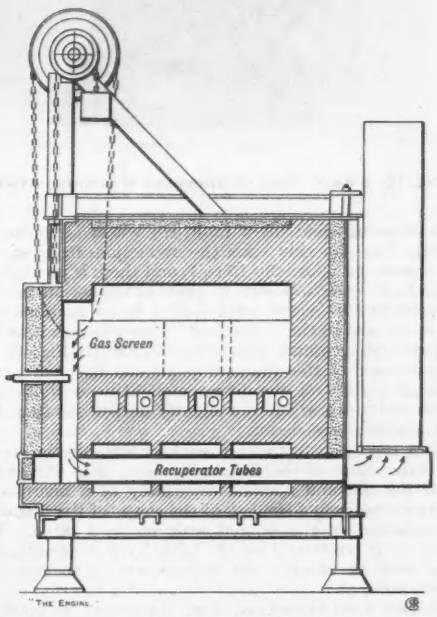


FIG. 9—HEAT-TREATMENT FURNACE—LUCAS

furnaces can be operated with fan blast up to 1400 deg. Cent., and are said to be free from objectionable roaring. For all high-temperature operations the muffle-protected type of furnace is not required, and when work has to be ground for finishing, the open type of furnace is often preferred. This furnace has proved to be particularly suitable for testing refractory materials. Temperatures of over 1600 deg. Cent. can be obtained, and the materials are tested under practical conditions.

Atkins (Peterborough), Ltd.

Thread grinding machines are exhibited by Atkins (Peterborough), Ltd., and the firm states that this process has now entirely emerged from the experimental stage. In our issue of December 30th, 1932, we described a thread-grinding machine as made by this firm, and that description covers the general features of the tools exhibited. Since that date, however, improvements have been made and new information has become available.

The process is one of form grinding, and hence its success is largely bound up with the methods employed to dress the edge of the wheel to the exact shape of the thread to be ground. In the wheel dresser devised by the firm, a single wrought diamond is used, and its motion is controlled by a stylus which is a reproduction to scale of the exact shape of the diamond, and which bears against a steel former made accurately, and to a large scale, in the shape of the Whitworth or other thread to be ground. In the engraving, Fig. 12, there is reproduced a drawing of the wheel-dressing mechanism for a single rib wheel. The former plate is seen at A. The device consists essentially of two slides interconnected to one another, and able to swivel about the main frame of the machine on the large ball bearings B. In addition, the upper "stylus" slide has a back-and-forth motion, which is transferred

by a pantograph mechanism at the correct "reduction" to the diamond slide. Back-and-forth motion of the "stylus" slide rocks the long lever C about the pivot D. A secondary link motion transfers this movement to the pivot rod E, which is rotated. At its lower end this rod carries an excentric pin which, engaging with the diamond slide, moves it back and forth according to the position of the "stylus" slide. Thus it will be seen that the diamond swivels about the same centre as the stylus, but at a smaller radius, and that its linear motion is reduced from that of the stylus in the same proportion. The former is usually made as a reproduction to × 25 of the thread, and the stylus is, of course, shaped as a reproduction to the same scale of the diamond point. The shape of the diamond is indicated in the sketch Fig. 14 (*a*).

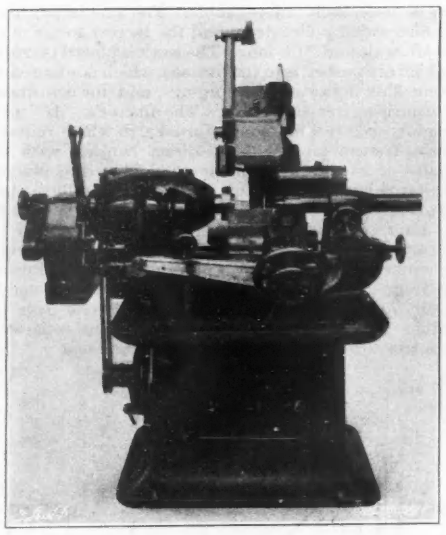


FIG. 10—SMALL THREAD GRINDING MACHINE—ATKINS

A dressing slide for a multi-rib wheel is shown in Fig. 11. In this case the reduction from stylus to diamond is usually 15 to 1, and there is no angular motion. The top slide is capable of motion in two directions at right angles, and these motions are transferred to the "diamond" slide through rotating rods and excentric pins. In the sketch Fig. 14 (*b*) the shape of the diamond point can be seen. It is usual to swivel the formers slightly so that each rib of the wheel takes a slightly deeper cut than the one which preceded it.

A special instrument is used for forming the stylus to the shape of the diamond point. It is illustrated in Fig. 13, and consists essentially of a microscope which projects a shadow of the shape of the diamond magnified to the desired scale on to a table. The stylus is positioned on the table by two dowels, and is filed to shape. No adjustment or focussing is required.

The tone engraving, Fig. 10, shows a machine fitted with a multi-rib wheel which has been designed primarily for the rapid production of hand taps and similar articles. It will take, between centres, work from ¼in. to 1in. in diameter by 6in. long, and the spindle is hollow to take the shanks of long taps. The grinding length is 2½in., and the maximum pitch eight per inch. The grinding wheel, 10in. in diameter, is mounted on a hardened spindle running in white metal bearings. Two hand wheels at the front of the machine operate the wheel and the diamond slide, and the amount of feed is indicated by a dial above the wheels. The slides can rock about a pivot, and this motion is controlled by a yard arm, which receives the feed and relief motions from cams mounted on the headstock. The work spindle runs in white metal bearings mounted in the headstock. Its slide is driven through gears, and relief for two, three, or four flutes is given by a single-lift cam. The spindle is also connected by gears to the traverse cam. The circular traverse cam gives the required lead to the work by traversing the work spindle. No reverse of the spindle occurs during the rapid work return motion. Thirty-three work speeds are provided by means of interchangeable belt pulleys, giving a range from 53 to 2176 r.p.m. Fully automatic operation is obtainable, and all that is necessary is to place the work between the centres, set the roughed thread in relation to the wheel by means of the pitch finder fitted to the machine and visible in the engraving, and start the work spindle. The machine will then feed to size and stop itself automatically. Either single or multi-rib wheel dressers can be used on this machine, and as an example of its productive capacity the makers state that forty ¼in. Whitworth taps per hour can be produced with a single-rib wheel. The machine is self-contained with a coolant tank and pump, and is driven by a single belt or self-contained electric motor.

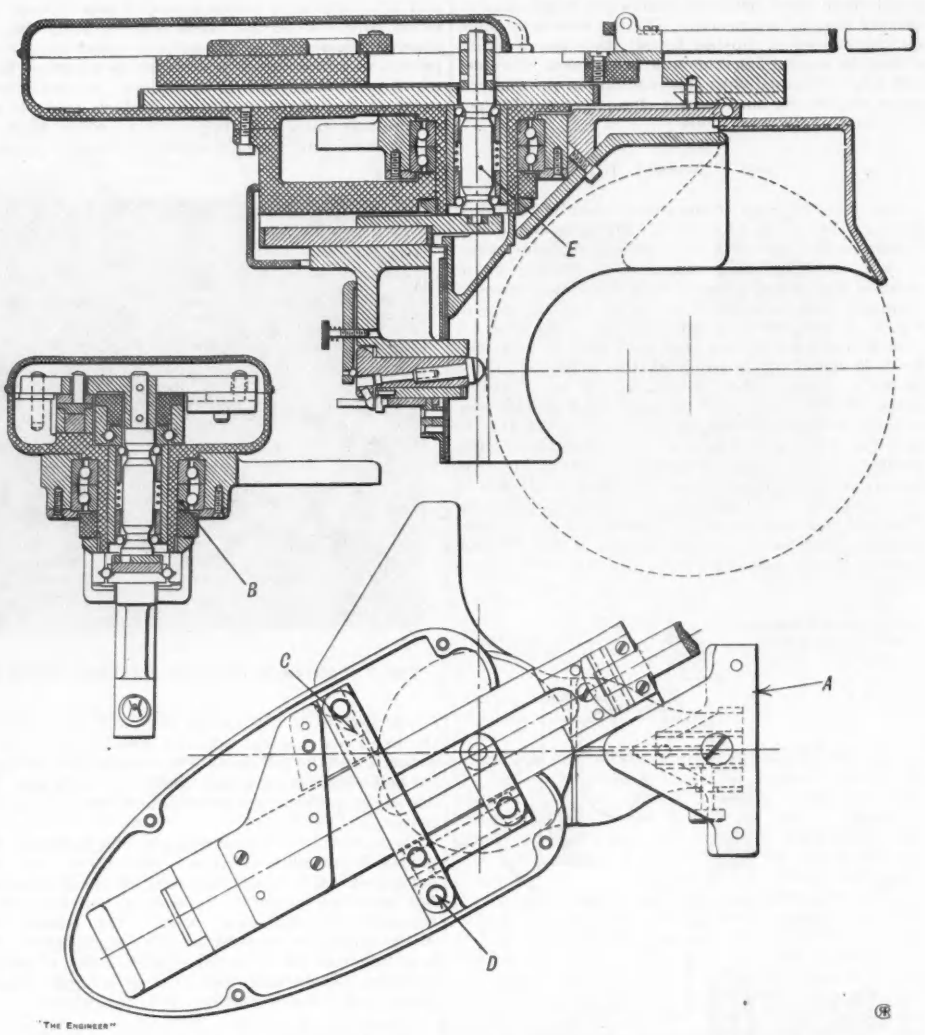


FIG. 12—WHEEL DRESSING MECHANISM FOR SINGLE RIB WHEEL—ATKINS

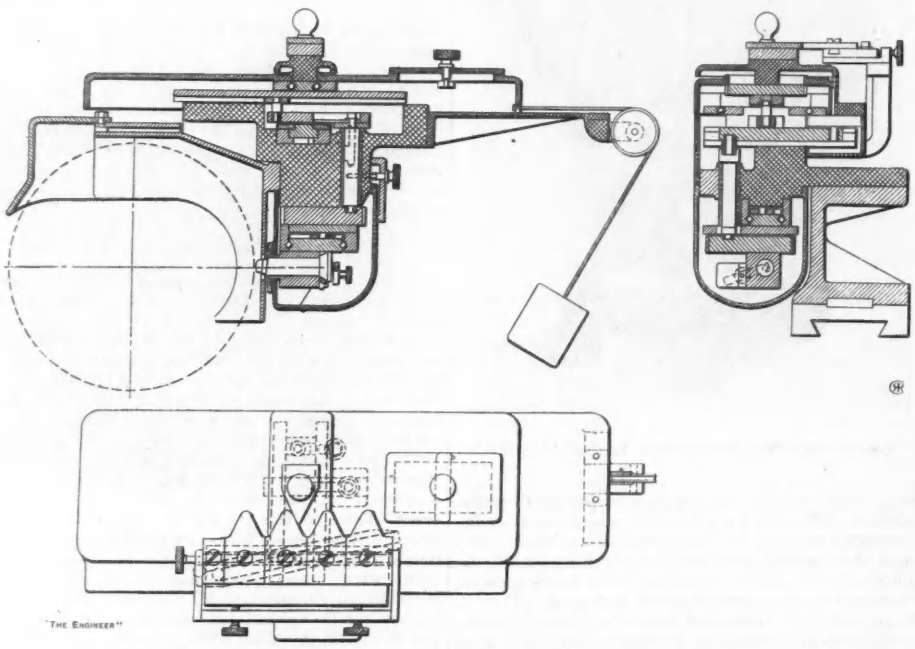


FIG. 11—WHEEL DRESSING MECHANISM FOR MULTI-RIB WHEEL—ATKINS

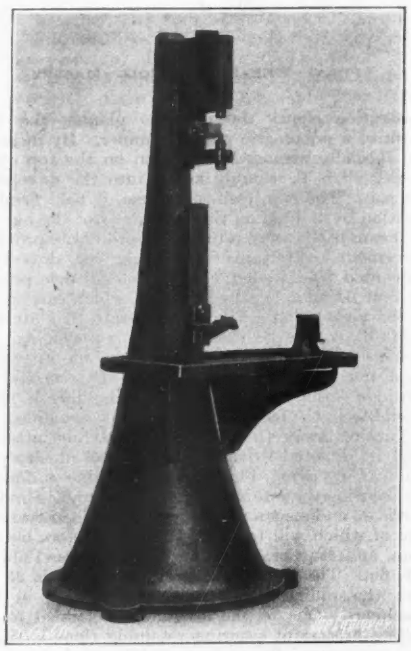


FIG. 13—STYLUS PROJECTOR—ATKINS

Another machine exhibited is similar to that which we described and illustrated in December,

1932. It is intended for general engineering purposes, and is suitable for the making of gauges, taps, chasers, lead screws, worms, &c. It has a wheel of the single-rib type, and the diamond feed mechanism is so designed that any amount taken off the wheel by the diamond automatically moves the wheel head in

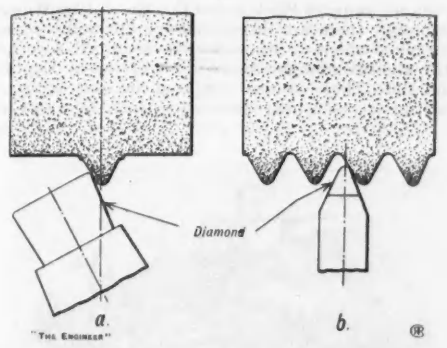


FIG. 14—SHAPES OF DIAMOND POINTS

relation to the work, so that it is not necessary to reset the wheel after dressing.

KITCHEN AND WADE, LTD.

On the stand taken by Kitchen and Wade, Ltd., of Halifax, there are to be seen a number of drilling and boring machines and three shaping machines. Of these, we have chosen for illustration in Fig. 15 a 5ft. radius drilling machine, which is representative of a new range in radii from 4ft. to 6ft. As will be seen from the engraving, the tool is very sturdily constructed. The column is 15in. in diameter on the ground portion, upon which the arm slides, and the arm itself is of an improved design, which resists elevating and twisting strains. The length of its bearing against the column can be seen in the engraving. At the top of the column there is mounted the reversing motor for elevating and lowering the arm.

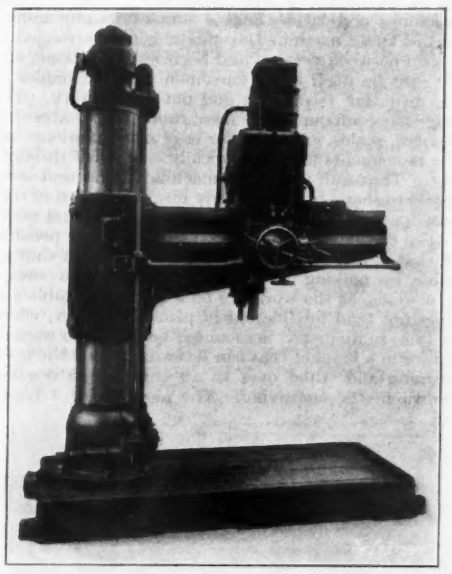


FIG. 15—5-FOOT RADIUS DRILLING MACHINE —KITCHEN AND WADE

The driving motor is mounted above the saddle, and both motors are controlled from a single lever on the right-hand side of the saddle. As will be seen from the engraving, all the controls are concentrated on the lower part of the saddle conveniently beneath the hands of the operator. The spindle has a feed of 15in. and eighteen speeds are available between 30 and 1000 r.p.m. These speeds are obtainable by the use of three levers to the right of the main hand traverse wheel. There are six feeds from 36 to 150 c.p.i., obtainable by the use of levers above the hand wheel. The vertical adjustment of the arm amounts to 2ft. 6in. All driving gears are made of 70 tons tensile heat-treated nickel chrome steel, and the flow of lubricant to them is maintained by an oil pump enclosed within the casing. Liberal use is made of ball bearings for carrying the shafts. In order that traversing and slewing shall be easy, the saddle and column are arranged upon special ball bearing and roller bearing mountings. Besides the automatic speeds and feeds, hand adjustments are provided. A single lever on the saddle locks the saddle and the sleeve bottom. Reversal for tapping is obtained through powerful friction clutches.

EDGAR ALLEN AND CO., LTD.

The practice of Edgar Allen and Co., Ltd., of Sheffield, in the manufacture of cutting tools with high-speed steel tips on shanks of cheaper metal is to weld on the tip rather than to braze it on, as has been the general practice heretofore, and a number of examples are exhibited on the stand. The tips are of Stag Major super high-speed steel, and are electrically welded on to shanks of 0·4 to 0·5 carbon steel or of manganese chrome alloy steel. The tip is made the full depth of the section, so that in grinding only the high-speed steel is cut away, and there is no liability for the grinding wheel to glaze over on account of having also to remove part of the softer shank, as is the case with brazed tips. Tests have been made with these tools to discover the security of the welding attachment, and show that the tool will shear off rather than break at the weld. A tool, for instance, of the 2in. by 1½in. size was being used to make a cut ⅜in. deep by ⅛in. feed in a steel casting at a speed of 40ft. Accidentally, the feed was increased to ¾in., but even then the tool was not damaged.

In manufacture, after these tools have been welded and rough ground, they are heat treated by being raised slowly to a temperature of about 850 deg. Cent., when they are transferred to another furnace, which quickly raises the temperature to between 1380 deg. and 1400 deg. Cent. They are then cooled off in a blast of dry air and given a secondary hardness by reheating to from 580 deg. to 600 deg. Cent., retained at this temperature for about five minutes, and allowed to cool off on the floor. A Brinell hardness reading of over 900 is in this way obtained.

Dry grinding on a free cutting wheel is strongly recommended by the makers. It should, they say be borne in mind that the wet grinding of high-speed steel carries with it the danger of the operator making too long and too hard contact with the wheel face. This causes local heating of certain parts of the face being ground, generally the centre, where the water cannot reach freely. On the tools being withdrawn from contact with the wheel, the water immediately impinges on this hot spot. The sudden cooling results in a grinding or surface crack, which develops under the vibration and pressure of the cut into a fracture. A piece may then break off when the tool is put back into service.

BIRMINGHAM ELECTRIC FURNACES, LTD.

Three "Birlec" electric furnaces, as shown in Fig. 16, are to be seen on the stand of A. C. Wickman, Ltd., of Coventry, agents for Birmingham Electric Furnaces, Ltd. One is suitable for operation at temperatures up to 1400 deg. Cent., for Wimet tipping, high-speed steel hardening, &c. The furnace is fitted with the maker's patented "certain curtain" atmospheric control equipment, which prevents scaling, pitting, de-carburisation, &c., thus reducing or even eliminating the use of grinding tools after hardening. The results of imperfect or uncontrolled furnace atmosphere, such as carburisation, de-carburisation scaling, and oxidation, are caused by the presence in the furnace chamber of either or both of two substances in excessive amounts, viz., oxygen and carbon. It is therefore essential that means should be provided for controlling the amount of these two elements. Perfect control is claimed to be secured in the "certain curtain" furnace by complete separation of the furnace heating from the atmospheric control. Gas and air are mixed and burnt outside the actual working chamber, and then forced into the heating chamber. Complete control is secured over the composition of the burnt gas, which

FIG. 16—GROUP OF ELECTRIC FURNACES—BIRMINGHAM ELECTRIC

displaces all the oxygen bearing atmosphere previously present, and prevents air entering the furnace, as shown in Fig. 17. Gas and air, controlled by valves, are admitted to the "atmosphere" combustion chamber A through the inlet B. A mixture indicator shows the rate of flow of the gas and air respectively, and enables the operator to establish the ideal atmospheric conditions which can easily be duplicated at any time. The burning of the gas and air is done in the combustion chamber, and not in the furnace. The resulting mixture is then forced upwards through a slot C, extending across the vestibule in front of the heating chamber, thus forming a curtain of gas which seals the mouth against ingress of air and fills the furnace with the neutral mixture. The "Globar" heating elements are shown at D, the water-cooled terminals at E, the refractory lining at F, the heat insulation at G, and the hearth plate at H.

The furnace to be seen in the centre of the illustration, Fig. 16, is designed for operation at temperatures up to 1000 deg. Cent., and, like the furnace already described and shown on the right of the picture, is fitted with "certain curtain" atmospheric control equipment. It is therefore well suited for hardening carbon and alloy steels, reheating carburised parts, preheating high-speed steels, &c., when the prevention of scaling and decarburisation is important. The third furnace, shown on the extreme left of the picture, is one of a range of furnaces for low-temperature heat treatment, such as tempering, secondary hardening, low-temperature annealing, and the heat treatment of aluminium alloys, &c. A patented

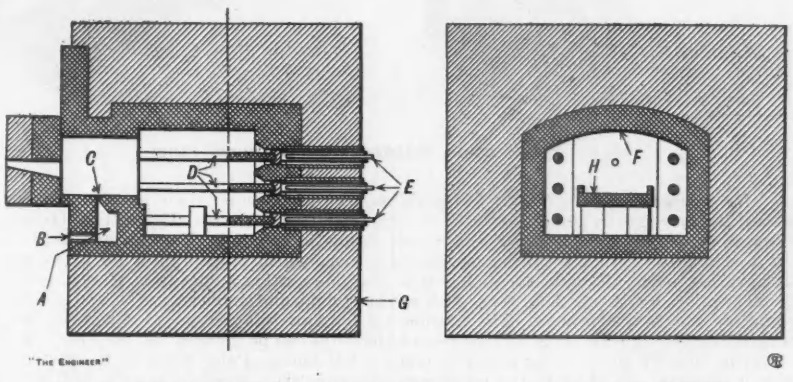


FIG. 17—ARRANGEMENT OF "CERTAIN CURTAIN" ATMOSPHERIC CONTROL

centrifugal fan maintains a circulation of air over the heating elements, and the charge is rapidly and uniformly heated.

HERBERT HUNT AND SONS.

There is a wide variety of automatic machines for making and grinding tools on the stand of Herbert Hunt and Sons, Old Trafford, Manchester, and we have

chosen those illustrated in Figs. 18 to 21 for description. That shown in Fig. 18 is designed for fluting and clearance milling twist drills from $\frac{1}{8}$in. to $\frac{1}{4}$in. in diameter. It has two fluting spindles and two clearance milling spindles, in pairs facing one another, which operate on four blanks simultaneously, so that one complete drill is finished in every advance and return of the work head. The blanks are held in chucks in a horizontal turret, which has six heads, so that while the cutters are working at four of the spindle stations, there are two free for loading and unloading. The movements are all automatic in so far as the milling operations are concerned, and the work head has an automatic feed with a quick return and indexing motion. The fluting heads can be adjusted to suit the angle of the spiral, and are so arranged that the milling of the flute thickens towards the shank end of the drill. At the end of the cut the heads move back about $\frac{1}{8}$in. from the work. The clearance milling heads are at the lower spindle stations and are equipped with a conical type of milling cutter. They also move clear of the work at the end of the cut. In order to facilitate the setting up of the machine, the two arbors which carry the fluting cutters are fitted with micrometer adjusting collars, and a micrometer adjustment on the head regulates the depth of the flute. The clearance cutters are adjusted in a similar manner, and can be moved endways along the blank to regulate the width of the land. The length of the flutes is determined by traverse stops to the work head, and change gears are provided for giving the correct feeds. The pitch of the spirals is also arranged by change gears.

A new machine is the tap sharpener shown in Fig. 19. It is arranged to grind a convex clearance which can be varied to suit all requirements for right and left-hand taps, and will take long taps, such as those used for screwing stay bolt holes. The machine can be changed over very quickly for grinding different kinds of taps, no finger support being required, and the grinding is uniform, according to the number of flutes. The flute-grinding attachment will rectify any uneven spacing and form uniform cutting faces. Taps can be ground in the flute at right angles to the rake of the thread or at a greater angle. The attachment can be swung well clear of the work when not in use. The table carrying the headstocks is of steel, and the length of travel is regulated by stops. The grinding wheel spindles run in ball bearings, and a pump is provided to supply a coolant. The main guard is of steel.

The machine shown in Fig. 20 is a special lathe for turning Morse taper shanks on drills and other small tools. It is very substantially built, as it is intended to work at high speeds with cemented carbide or alloy tools. The bed, it will be seen, is a massive box, which has facings for the fast and loose headstocks for the turning slide at the front and for a cross slide at the rear. The sliding saddle has long bearing surfaces, and its slide can be swivelled for taper or parallel turning. The cross slide is arranged for multiple tools for ending, recessing, &c. Both slides are operated by large-diameter screws with self-acting feeds and rapid reverses. They have automatic knock-off stops which act after the tools have returned to the original starting positions. The fast headstock has a mandrel of large diameter, which runs in Timken roller bearings, and is driven by a worm and worm wheel. The speed is changed by means of stepped cone pulleys. The feeds are also changed by cone pulleys. A compensating driver is arranged in the spindle nose on the principle of the Oldham coupling and permits high speeds and feeds to be used without chattering. There is a large tank in the base into which the cuttings drop clear of the slides. It can easily be removed for cleaning purposes.

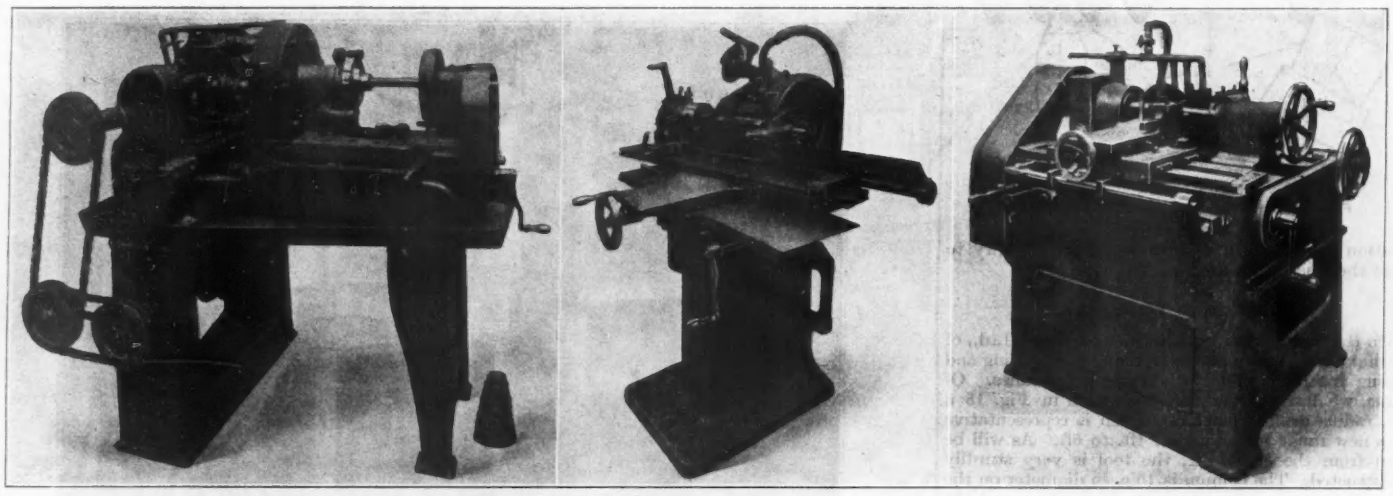
The two machines shown in Fig. 21, represent twist drill sharpening machines, which are alike, except that one is for hand operation, while the other has automatic motion. They are made in six sizes for drills ranging from 0·015in. to 4in. in diameter. The drill is held in a self-centring chuck, which will hold either taper or parallel shanks, while the point end is supported in a bush. The drill is, of course, revolved during the grinding. The clearance is given by a cam motion, which repeats itself for every cutting edge. Varying cutting angles from 90 deg. to 180 deg. can be ground, and the clearance altered to suit the drilling of hard or soft metals. Drills with two, three, or four lips can be ground, and they may be either right or left hand. Point thinning is effected by moving the cross slide, which brings the drill into the correct position under the thinning wheel. No resetting of the drill is necessary. The angle of the wheel is such as to grind along the flutes. Ball and roller bearings are fitted throughout, and the swivel slide has hard steel facings with needle rollers and a ball-bearing pivot. The cross slide is operated by a quick-pitch screw and hand wheel in place of a lever. Many of the castings in the machine are of steel to enable it to be driven hard and yet produce a good finish.

There are also on this stand an automatic tap relief grinding machine, for the manufacture of quantities of small taps, which is equipped with a dust extractor; a triple head fluting machine, which is entirely automatic and flutes three taps at once, and several others connected with the manufacture of drills and taps.

WADKIN AND CO.

On the stand of Wadkin and Co., Green-lane Works, Leicester, there are displayed several wood-working machines which we have already described, together with the two new saw benches illustrated by Figs. 22 and 23. There is also exhibited an electric cross-cutting and trenching machine, with an 18in. saw, in which the saw is moved—not the work. It will cut square, and at angles up to 45 deg. There is also a little electric planer and jointer capable of planing up to 6in. wide; a 36in. band saw; some sanding machines and lathes, and a semi-automatic miller. In this latter machine the spindle head is arranged to swivel between vertical and horizontal positions, and the spindle itself has a movement at right angles to the arm for feeding in and out of the work. The table has compound movements and incorporates stop devices, scales, and rules for easy manipulation. All the movements are mechanically controlled throughout. The result is that the machine can be used accurately to shape practically any form of pattern or core box in a fraction of the time necessary for hand work.

The circular saw illustrated by Fig. 22 is peculiar in that it has a canting spindle, instead of a canting table, for making cuts at an angle. The advantage is obvious, as the work lies on a horizontal table and does not tend to slide out of place. The saw, which is 18in. in diameter, is mounted on a spindle with its motor in a bracket that can be swung inside the main framing and tilted over to an angle of 45 deg., as shown in the engraving. The motor is of 4 horse-power, and runs at 1800 revolutions per minute. The saw bracket can also be adjusted vertically with respect to the table, so that the saw may be set for such jobs as rebating, grooving, &c. There is a guard below the table which covers the saw in all angular positions. This guard totally encloses the lower part of the saw, and enables the draught made by its rotation to be used for the disposal of the sawdust. The front is hinged to facilitate changing the saw. There is also a top guard for the saw which complies with the Home Office requirements, and the riving knife, which is curved on its front edge to suit the diameter of the saw, is supported on the bracket carrying the saw and motor. The horizontal table is divided into two parts, the front portion sliding on ball bearings, which are carried on a frame supported on an extension of the fixed table. The back portion of the table is stationary. The front portion of the



FIGS. 18, 19 AND 20—TWIST DRILL FLUTE MILLING MACHINE, TAP SHARPENING MACHINE, AND TAPER TURNING LATHE—HUNT

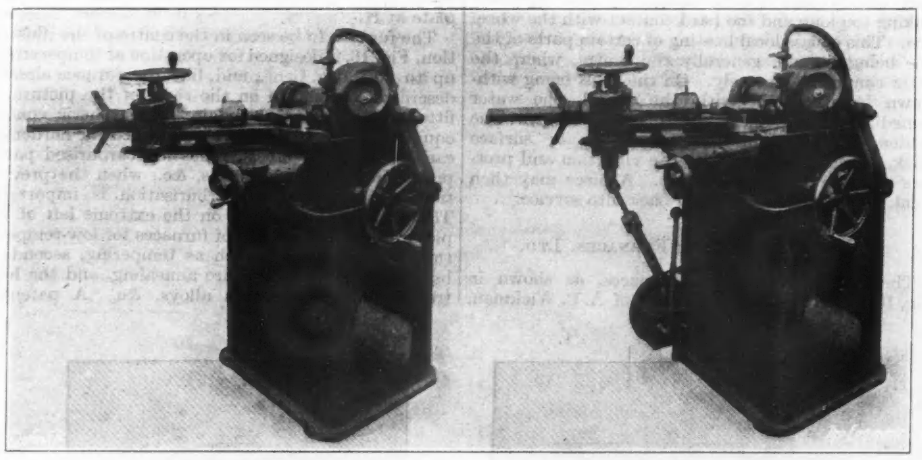


FIG. 21—TWIST DRILL SHARPENING MACHINES—HUNT

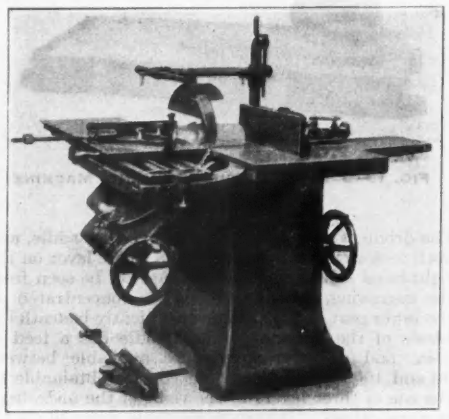


FIG. 22—CANTING SPINDLE SAW—WADKIN

table can be drawn out to the extent of 4in., so that wide cutters can be substituted for the saw. For ripping, the fence can be set back to a distance of 24in. from the saw, which will also cross-cut to a depth of 4in.

The saw bench shown in Fig. 23 has a rising and falling table, and a saw 20in. in diameter. It is what might be described as a general utility saw, and is driven by a 5 horse-power motor. It can, of course, be arranged for direct belt driving if a line of shafting is available. The saw spindle runs in ball bearings and is arranged to take multiple saws, cutterblocks, grooving saws, &c. The spindle is bored at the back to take boring and slotting bits.

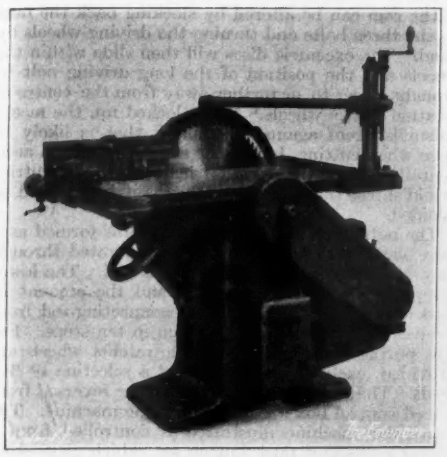


FIG. 23—20-INCH SAW BENCH—WADKIN

The ripping fence can be canted to an angle of 45 deg., or can be turned right over for cross cutting. Like the previously described machine, the saw is totally enclosed below, so that its innate draught can be used to carry away the sawdust from the front. The driving motor is controlled by a Brookhurst starting panel.

JOHN LANG AND SONS, LTD.

Ten lathes are shown by John Lang and Sons, Ltd., of Johnstone, near Glasgow. There are 20in. and 16in. swing high-speed sliding, surfacing and screw-cutting lathes, 13in. and 17in. swing Lang "Junior" lathes of the same type, 20in. and 26in. swing high-speed surfacing and boring lathes, 17in. and 13in. swing special precision toolroom lathes, and two Lang-Heinemann multi-cut lathes arranged for chuck work with boring loose head. One of the latter machines, with a maximum swing of 16½in., height of centres 8½in., and distance between centres of 5ft., is shown in Fig. 24. The all-gear fast headstock is arranged for eight spindle speeds and is driven by a large friction pulley with a brake for bringing the spindle quickly to rest. Speed changes are obtained by sliding gears of nickel-chrome heat-treated steel with the teeth ground after the treatment. The

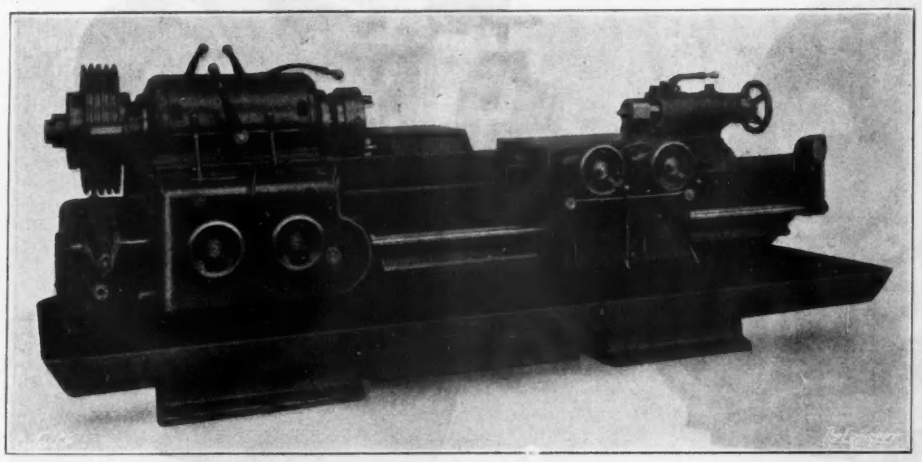


FIG. 24—MULTI-CUT LATHE—LANG

sliding gears are mounted on solid splined shafts with ground splines, and all shafts run in ball or roller bearings. The hollow ground spindle of hard crucible steel is mounted in roller bearings, the front spindle bearing being of the Lang's patented "pre-loaded" spherical roller type, which takes the radial load and end thrust on the spindle.

The deep well-ribbed bed, capable of withstanding all loads without deflection, has generously proportioned guiding surfaces, and there is a deep tray for receiving the cuttings and lubricant. Two front sliding surfaces are provided for the sliding carriage, the outer one being of saw tooth form, giving on one side a surface to take the pressure of the cut and the whole forming a vee to compensate for wear. The other guide is flat.

The rack for providing the feed is placed in the centre of the two guides and prevents any tendency of the saddle to tilt under heavy pressure. The surfacing slide and tailstock guiding surfaces are arranged at the back of the bed and consist of a large saw tooth shaped vee on the top and a deep vertical guide at the back. Another guide is provided in the centre of the bed for the tailstock to ensure rigid clamping. A T groove runs the full length of the bed and there is a wide opening between the guide and the bed to allow cuttings to fall into the tray.

The front or sliding carriage is used for general sliding work and has one cross slide with short beds and two for longer sizes. The front slide is exceptionally long and protects the bed guides from cuttings and lubricant. For accurate adjustment of the cut a micrometer index is provided and a stop to determine the depth.

Primarily the back carriage is used for surfacing. The cross slide has square guides and wear is taken up by solid taper strips. The feed rack is in the centre and is fully protected from the cuttings. The principal parts of the feed mechanism, such as shafts, racks, and pinions, are made of high-grade steel. A universal back saddle can be supplied with a swivel slide, which is attached to the surfacing saddle by six bolts, two of which are placed in front to take the direct upward thrust and the nuts of these bolts are only accessible after the slide has been withdrawn. On the front and back carriages the tool holders are interchangeable.

The self-acting feed is provided by spur gearing from the spindle to the feed box, which gives six positive feeds through the sliding gears and tool clutch, which are operated by two conveniently placed hand levers. The carriages can be operated together or separately according to the nature of the work. On each carriage the feed can be disengaged automatically at any desired point by a graduated disc having adjustable stops for each slide. By means of two pairs of change gears the ratio between slides and surfacing feeds can be altered and the amount of feed may be changed easily and quickly by two levers on the feed box. At the same setting a pulley, for example, can be rough turned with a feed of 0·02in. and finished with one of ⅛in. by means of the levers. The combination of feed box and change gears gives thirty-two graduated feeds ranging from 0·002in. to 0·125in.

The quick power traverse is provided for rapid withdrawal of the tools to their original position after the cut has been completed and also for convenience of setting. It is put into action by moving the feed lever in the opposite direction to the feed, and it continues to operate until disengaged by the automatic trip or by releasing the lever. By using the feed lever for both feed and quick-traverse motions the possibility of both being in action at the same time is obviated. For mass production work the quick withdrawal of the two carriages can be set in motion automatically so that the operator need only stop and start the spindle, chuck the work, and engage the feed.

The tailstock is mounted on the back guiding surfaces of the bed and is secured by strong clamping bolts, various types of centres being used according to the nature of the work. An oil pump supplies the lubricant, which is conducted to the tools by piping and flows into a large tray. Most of the shafts and bearings are oiled from a common reservoir and the amount of oil can be adjusted for each bearing and can be turned off by a tap at the end of the day's work.

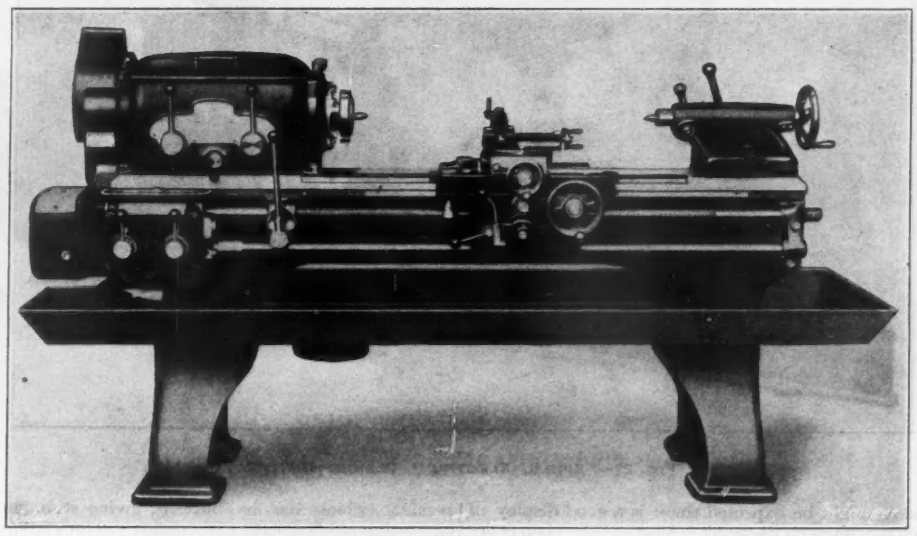


FIG. 25—"JUNIOR" LATHE—LANG

One of the Lang "Junior" lathes mentioned at the outset is shown in Fig. 25. Two of these lathes are shown, one with a 13in. swing and 6ft. bed with 30in. between centres, and the other with a 17in. swing, 6ft. bed with 24in. between centres. In each case the bed has raised vees to guide the saddle and loose head, and diagonal ribs to resist twisting strains. The bed surfaces are protected by covers fitted to the saddle. The all-gear head gives six spindle speeds ranging from 20–400 r.p.m., and "pick-off" gears give a further range of six speeds. All gears are composed of nickel-chrome heat-treated steel with ground teeth, and splined shafts have ground splines. A multi-plate friction clutch is provided on the constant-speed driving shaft, the spindle rotation being controlled by a lever at the front of the bed. A patented "pre-loaded" spherical roller spindle bearing is provided. Six feeds, 12–144 cuts per inch, are obtainable, and there is a screw-cutting gear-box with change wheels for Whitworth and metric threads.

BROOK MOTORS, LTD.

Electric motors of various types, as supplied to machine tool manufacturers, are exhibited by Brook Motors, Ltd., of Empress Works, Huddersfield. A machine of considerable interest is the reversible motor shown in Fig. 26. It is capable of reversing thirty times per minute on load, and is suitable for driving drilling and other machines that necessitate rapid reversal, as when tapping condenser tube plates. To make it suitable for the duty, the machine

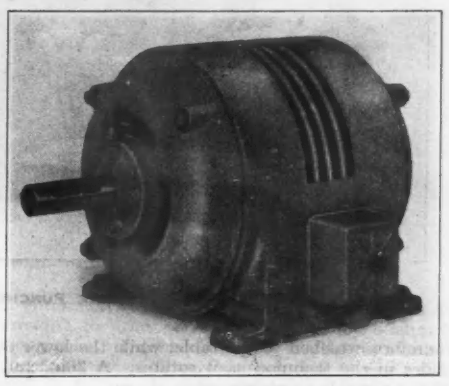


FIG. 26—REVERSIBLE MOTOR—BROOK

has an oversized shaft, bearings and lubricators, an elongated carcase, and small diameter rotor to reduce the inertia. The rotor is both splined and keyed to the shaft, which can reverse from 1500 r.p.m. in one direction to the same speed in the opposite direction within three-fifths of a second. As the motor eliminates hand reversing gears on the machine tool, it considerably reduces the time required for tapping a series of holes.

THE BUTLER MACHINE TOOL COMPANY, LTD.

The name of the Butler Machine Tool Company, Ltd., of Halifax, has long been associated with planing machines, shaping machines and slotters, and as might be expected there is a good display of such machines on its stand. Amongst the planers are two of the open-side variety in which the table is driven by the same kind of link motion as that used for the firm's shapers. We have described this motion in previous articles in THE ENGINEER. It will be remembered that instead of the usual small pivot at the end of the link, a large-diameter trunnion acts as a pivot and also has a large hole bored across its axis. The link has a round shank at the lower end, which is a sliding fit in the cross hole. Thus the upper end of the link can travel in a straight line and is therefore attached to the table, while the lower end slides in the trunnion as it rotates. A 36in. and a 48in. open-side crank planer are shown.

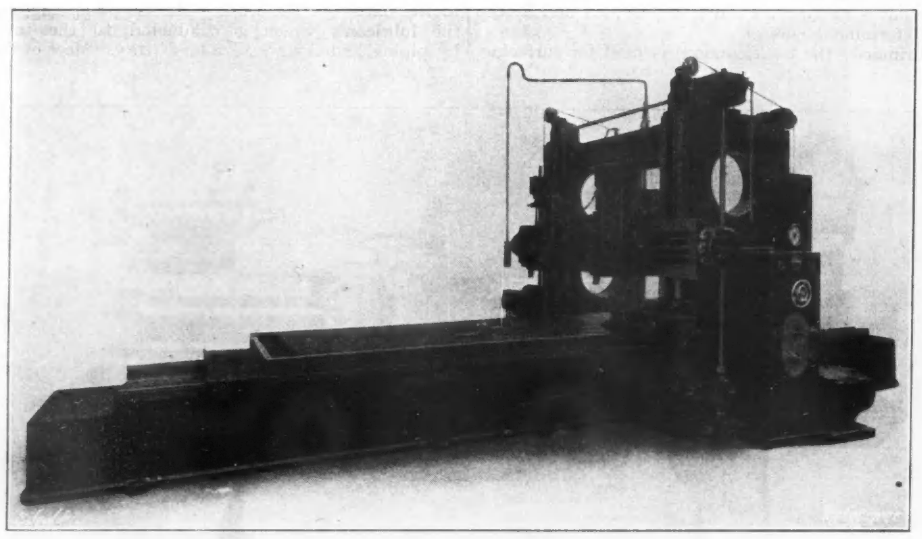


FIG. 27—"SPIRAL ELECTRIC" PLANER—BUTLER

The 12ft. by 4ft. by 9ft. spiral electric planer, illustrated in Fig. 27, is driven in a different manner, from a forced field reversing motor through an "all-spiral" transmission. The first worm is of nickel-chrome steel, the hollow tooth worm wheel of hard phosphor-bronze, and the large table worm of high-tensile steel. Many of the features of the machine, such, for instance, as the fact that the length of the bed is double that of the table, may be seen or inferred from the engraving. All the electrical control mechanisms are housed within a welded steel panel secured to the front upright. Fourteen feeds are available, from $^1/_{64}$in. to $\frac{1}{4}$in., and they can be selected or changed while the machine is in motion. Regulators built into the face of the feed panel serve to change the cutting and return speeds, and an electrical tachometer, mounted above, registers the speed in operation. Cutting speeds of anything between 20ft. and 200ft. per minute and return speeds between 110ft. and 220ft. per minute can be obtained. The machine is equipped with four tool-boxes, two on the cross slide and one on each of the uprights. The main control of this planer is concentrated in the pendant, which has five buttons, giving stop, start and inch motions for the main motor and forward and reverse for the power traverse. Power traverse from these buttons can be operated with the feed engaged.

A slotting machine and a shaper which are to be seen on the stand are illustrated in Figs. 28 and 29. One of the greatest points of interest in the slotter is the method of driving the ram. Machines of this type may be driven either by a belt through fast and loose pulleys or by a motor through gearing. In either case a main drive shaft mounted across the back of the machine is rotated. This shaft carries at one end a large fly-wheel to ensure smoothness of cutting, and passes through a gear-box built into the back of the tool, which gives four alternative speeds. Thence through reduction gearing the drive passes to twin driving wheels mounted in large cast iron bearings in the main body of the machine. The face of one of these wheels can be seen in the engraving. Each wheel bears within it, excentrically placed, two discs, which are held in position by the three bolts visible in the engraving. Two of these bolts serve to lock the discs against an internal shoulder in the wheel. But the third passes right through from back to front through all the discs and wheels. Between the two wheels this long bolt carries a hardened steel bush on which a phosphor-bronze die is free to revolve. When the three bolts are tightened the front pair of discs is locked up tightly with the front wheel by two of the bolts, while the third locks the rear wheel with its two excentric discs to the front wheel through the steel bush. Both wheels are driven and the whole assembly revolves together. The bronze die, which is free to revolve on the steel bush, is capable also of sliding within a cast steel link formed as a bell crank lever. The second arm of this link is connected to the ram by a forged steel connecting-rod, which is so arranged that on the cutting stroke it is in tension. It will be observed from the foregoing that the stroke of the ram can be altered by slacking back the nuts on the three bolts and turning the driving wheels by hand. The excentric discs will then slide within the wheels and the position of the long driving bolt be brought closer to or further away from the centre of rotation of the wheels. When locked up, the mechanism is proof against any shock that is likely to arise when cutting, but in the event of the ram accidentally fouling the work, for instance, the excentrics would slip so that damage to the main drive would be avoided.

The outer surface of the rear wheel is formed as a cam plate, from which the feed is operated through two slotted levers and a connecting-rod. The lower lever operates a ratchet wheel, and the amount of feed is varied by adjusting the connecting-rod from twelve up to ninety cuts per inch in ten steps. For this purpose two interchangeable ratchet wheels are provided, each of which provides a selection of five feeds. The feed is stopped, started, or reversed from a feed control box at the front of the machine. The particular machine illustrated is controlled from a portable pendant push button set, which gives stop, start, and inch movements to the main motor. The stop button operates electric braking on the motor. Many other details of the design of the machine which have not been mentioned can be seen in the engraving.

On more than one occasion in the last two years we have described in the pages of THE ENGINEER new shapers brought out by the Butler Machine Tool Company, Ltd. There is a very fine show of these machines on the firm's stand. In nearly all of them the ram is driven through the trunnion link motion, which was mentioned earlier in this article. The little 8½in. stroke toolroom shaper, illustrated in Fig. 29, however, has a stroke motion of the Whitworth type, which gives a movement variable from zero to the maximum, and also allows the position of the stroke to be varied. A further advantage of this form of drive, particularly in an accurate toolroom machine, is that the cut starts and finishes slowly, so that sharp edges on the finished work can be retained. This shaper is driven by belt from a line shaft to a friction clutch pulley. The stop and start lever applies a brake so that the ram may be "held" in any position. From the main driving shaft the power is transmitted through a four-speed gear-box to the single helical final driving wheel and pinion.

As befits a toolroom machine, this shaper is capable of performing a large variety of work. Its table has a circular swivelling movement through 360 deg. and the table top may be tilted up to an angle of 15 deg. A standard vice supplied with the machine has an indexed swivel base and a swivelling jaw. In addition, a taper vice is built into the side of the table.

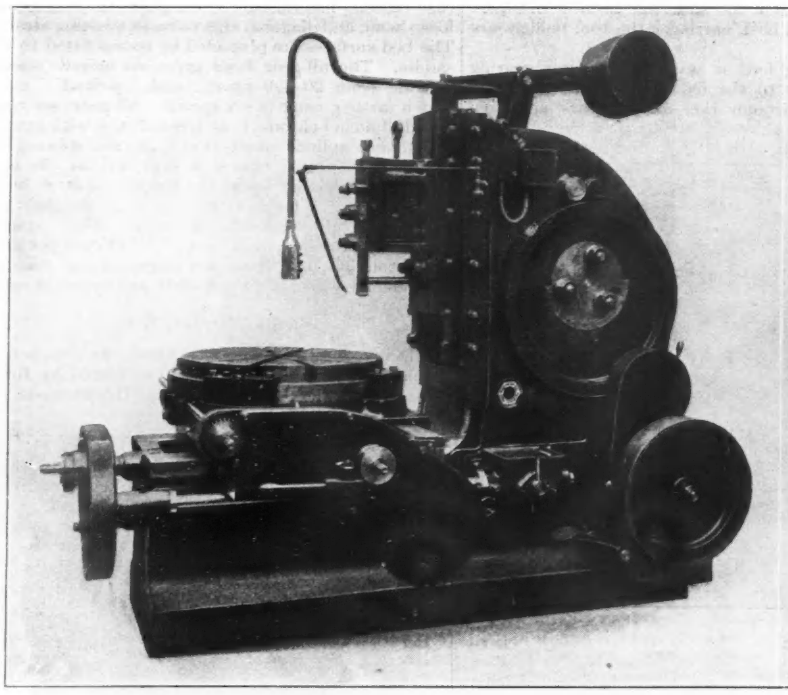


FIG. 28—12½-INCH STROKE PUNCHER SLOTTER—BUTLER

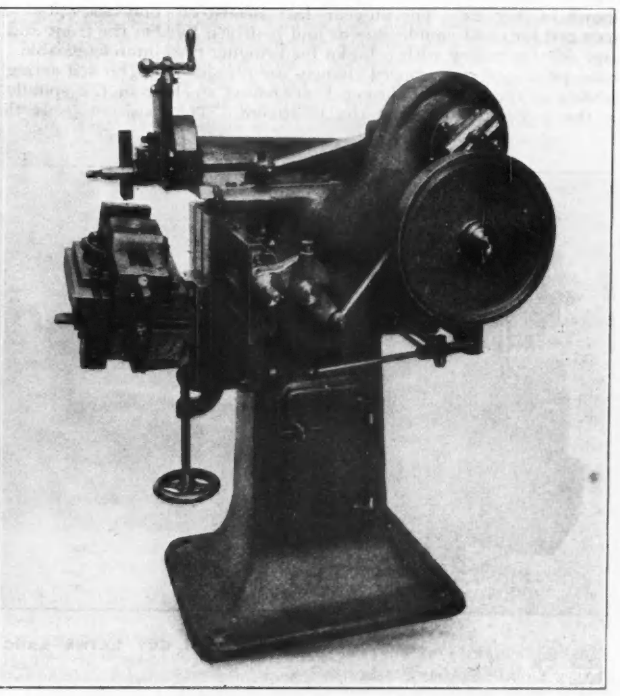


FIG. 29—8½-INCH STROKE TOOL-ROOM SHAPER—BUTLER

The tool-box, too, as will be seen from the engraving, is arranged to swivel. Various attachments, such as a dividing head, are available when special work has to be carried out. The universal nature of the various fittings of the machine make it suitable for machining such things as cutter bars, recess bits, and formed tools.

KENDALL AND GENT (1920), LTD.

A wide variety of machine tools is shown by Kendall and Gent (1920), Ltd., of Gorton, Manchester, including those which we illustrate in Figs. 30, 31, 32 and 33.

The first of these—see Fig. 30—is an open-sided, vertical and horizontal milling machine, with a capacity of 3ft. 9in. wide by 3ft. high by 7ft. long. It has a vertical spindle on the slide on the arm, and a horizontal spindle on another slide on the column, so that two faces can be machined at once and resetting of the work avoided. A wide range of cutting speeds and feeds is provided for working on such divergent materials as steel and duralumin. The arm carrying the vertical saddle is operated by a separate reversible motor controlled by push buttons, with limit switches to prevent over-running. The saddle is provided with hand and variable self-acting feeds and a rapid power traverse for setting purposes. The horizontal saddle on the column can be adjusted either by hand or power. The gearing for driving the spindles is mounted on ball bearings, and is controlled by push buttons from the operator's position. A special feature of the machine is the control gear, by means of which the two motors for the driving and the feed gears are interlocked in such a manner that should the spindle-driving motor fail the saddle and table feeds are immediately put out of action.

The other milling machine which we illustrate—see Fig. 31—has a single vertical spindle driven by a double-voltage motor mounted on the slide, and separate motors for traversing the table and the head.

The bed is of box section, and rests on the concrete foundation throughout its length. Side pockets are cast integral with the bed to receive the uprights and a tank is formed at one end into which the cutting coolant drains. The table is provided with longitudinal T slots, which are cut from the solid, for the holding-down bolts. It has a self-acting feed traverse in either direction by means of a semi-circular rack meshing with a worm. The thrust of the worm is taken by ball washers. A quick hand and power traverse is also provided for setting the work, and there are automatic stops for the self-acting feed. The main operating position is arranged on the left of the machine, and there is a directional control lever for the traverses, which shows at a glance how the gears are set. Automatic interlocking is arranged for. The cross slide carrying the milling head is raised and lowered by its own motor, which is mounted in the middle of the cross stay, and drives through worm and bevel gearing two large-diameter screws in the uprights. Provision is made by means of an adjustable nut for correcting the parallelism of the table and cross slide.

The milling head on the cross slide is, as already stated, driven by a double-voltage motor, with which a speed variation of 5 to 1 can be obtained. This, together with a high and low gear change on the head, enables a range of twenty different speeds to be obtained with a very simple gear arrangement and a minimum number of levers. The final drive to the spindle is through a high-efficiency worm and wheel. The spindle is of high carbon steel and has six splines in the driving part. It runs in ball and roller bearings, and the front end is carried in a large-diameter sleeve. A fine micrometer adjustment is provided by means of a worm and wheel and rack and pinion, and the spindle and sleeve can be locked in any position. The spindle nose has a large-diameter flange with driving keys for big face cutters, and is bored taper for cutters with shanks. The lubrication of all the bearings in the head is effected automatically. The horizontal feed of the milling head is done by a separate motor and an eight-speed gear-box. All the motors, by the way, are of 5 H.P. The machine will admit work pieces 4ft. wide by 4ft. high by 10ft. long, but the table has a traverse of 11ft. 9in.

Several machines for threading bolts are shown, one of which we illustrate in Fig. 32. This machine is capable of screwing bolts up to 2in. in diameter and tubes up to 3in. It has a guide screw control to the carriage for cutting taper threads. There is also a smaller machine for screwing up to 1in., in which speed change is obtained through a change-pole motor, and another for tubes up to 6in. in diameter. All these machines are equipped with the makers' patented die head, which has tangential chasers that enable the first and the finishing cuts to be taken without stopping the machine. The chasers are made of high-speed steel, and are held by clamps of nickel-chrome steel, which are arranged to open automatically when the carriage reaches the end of the cut. They can also be opened by hand. The chasers are interchangeable to such an extent that the makers can supply one piece to fit into a set of four, and they are so designed that opposite ends can be used for right or left-hand threads. Grinding is effected on the ends and does not alter the contour of the cutting edge. The spindle is carried in parallel bushed bearings, and is bored to pass the largest stock for which the machine is intended. It is automatically lubricated. The carriage is mounted on hardened steel bushes sliding on chromium steel bars in the bed, and means are provided for the easy readjustment of alignment at any time. The traverse along the bars is obtained by means of an inverted rack and pinion. The work is held in a self-centring vice having interchangeable hardened steel serrated jaws. The nuts for operating the screw are made from nitrided steel and are independent of the jaw carriers.

The broaching machine shown in Fig. 33 has a stroke of 44in., and will broach out a hole 1¼in. square from round in mild steel. The cutting speed may be from 6ft. to 24ft. per minute in four steps. It is equipped with a hydraulic cushioning device that takes the pull of the broach against an oil buffer

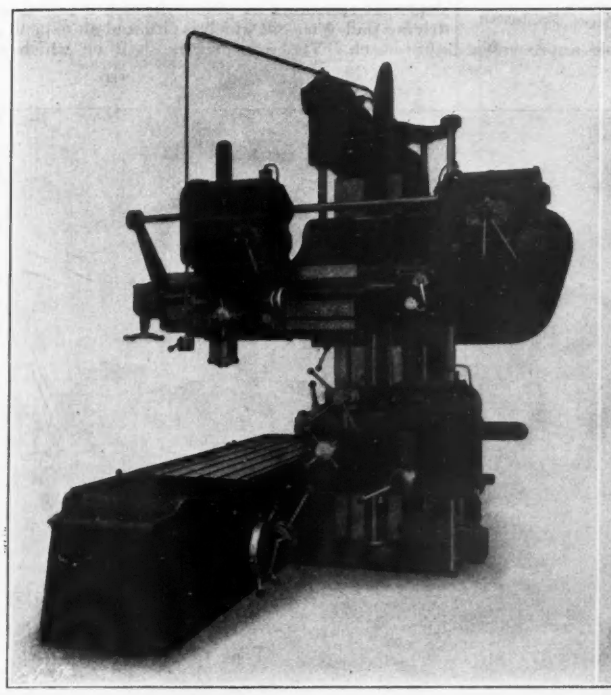


FIG. 30—OPEN-SIDE MILLING MACHINE—KENDALL AND GENT

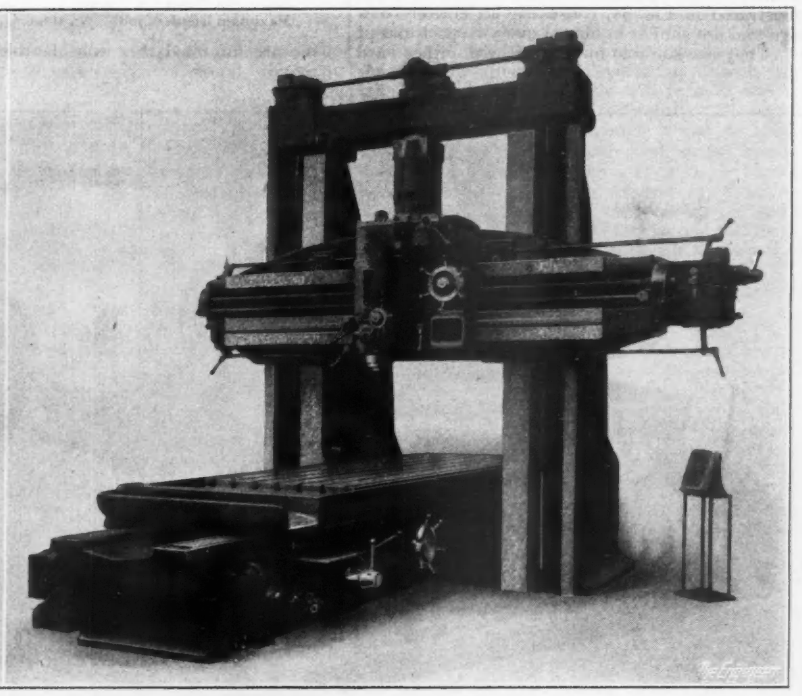


FIG. 31—HORIZONTAL PLANO-MILLING MACHINE—KENDALL AND GENT

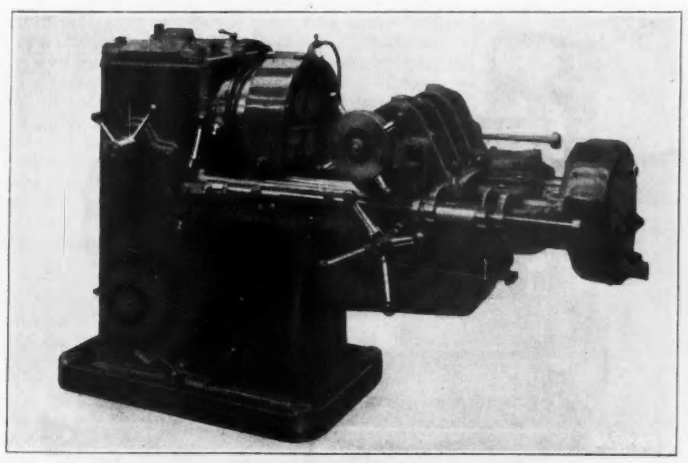


FIG. 32—SCREWING MACHINE—KENDALL AND GENT

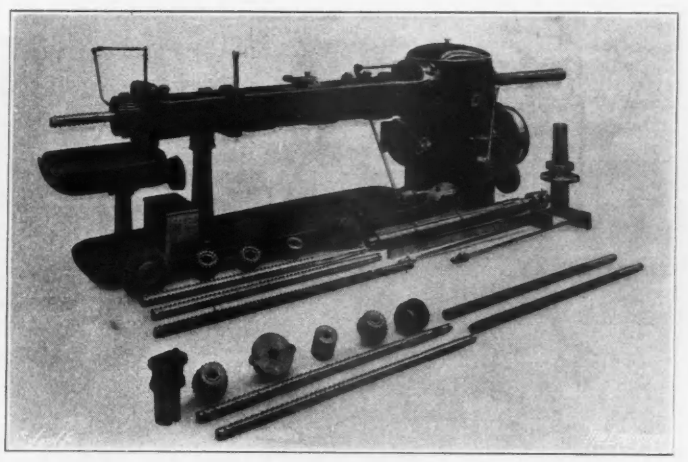


FIG. 33—44-INCH BROACHING MACHINE—KENDALL AND GENT

and registers the load on a dial gauge, which helps the operator in deciding when the broaches require regrinding. The pull is effected by a four-start thread that gives an efficient thrust angle with a minimum of friction in the nut. The tension is taken by a ball thrust bearing. There is a four-speed gear-box, in which only the gears in action are kept running, and a cone friction clutch in the drive. The running parts in the head are all lubricated by means of a pump.

B.S.A. Tools, Ltd.

On one of the stands taken by Burton, Griffiths and Co., Ltd., of Birmingham, a number of machines made by B.S.A. Tools, Ltd., also of Birmingham, are exhibited. Two screw automatics, the larger of which is illustrated in Fig. 34, constitute an entirely new design and are similar in almost every respect except size. They are suitable for dealing with either hard alloy steels or softer materials at high speed. The drive, which may be through a belt or directly from an electric motor, is taken to a gear-box situated within the base of the machine. Two types of gear-box are made. The "A" type gives two automatic forward and two automatic reverse speeds, while the "B" type has pick-off wheels and will give either two forward speeds or one forward and one reverse speed. In the "A" type gear-box the ratios are selected by means of clutches, the faces of which are Celeron lined. From the gear-box power is taken to the main spindle through two duplex chains. The main spindle is carried in pre-loaded roller bearings and adjustment is provided for taking up end thrust. A pump fitted in the base of the machine lubricates all bearings except those of the slow moving cam shaft and the shoes operating the speed change and the feed. The pan of the machine is so arranged that swarf can be removed at one end, and provision is made for the fitting of a swarf conveyor if it is required. Visitors to the stand should observe how, although the main driving mechanism and the gear-box are completely enclosed within the base, they can easily be examined in position or removed for more complete inspection. The machine is built either with a long or a short stroke turret, the latter arrangement having the advantage that the speed of the back shaft is increased from 120 r.p.m. to 240 r.p.m., so that on high-speed free-cutting material there is a considerable saving of time when indexing and feeding stock. The following table gives some particulars of the capabilities of the larger machine, which is known as the 1¼in. S.S. Automatic :

	L.H.	R.H.
"A" type.		
Maximum spindle speed	1790	895
Minimum spindle speed	180	90
Number of speed changes	14	14
"B" type.		
Maximum spindle speed	1725	—
Minimum spindle speed	71	71
Number of speed changes	24	24
"A" and "B" types.		
Maximum length of job	4in. fed	3in. turned

We are informed that considerable improvement has been made to the design of the single-spindle chucking automatic made by the firm. A machine of this kind is illustrated in Fig. 36. Like the screw automatics, it can be driven either through a belt and pulley or by a built-in motor unit. All the shafts and clutches in the gear-box are now mounted on anti-friction bearings, and two automatic speed changes are obtainable through multi-plate clutches. The head is driven through pick-off gears, which give a range of speeds from 32 to 845 r.p.m. The spindle itself is mounted on Timken taper roller bearings and all the speed gears are spiral. Four automatic changes of feed are available. Independent cams operate the front and rear cross slides, and they can readily be set relative to each other or to the turret cam drum. The turret has four faces and each face is operated by an independent cam so that complete flexibility can be obtained if desired. According to the makers, the complete idling time for four indexes inclusive of the advance and return motions is only twenty seconds.

There are also to be seen on the stand some of the B.S.A. centreless grinding machines, but since these tools were recently fully described and illustrated in The Engineer, there is no need to refer further to them.

A. C. Wickman, Ltd.

Besides the many imported foreign machine tools which are described in this Supplement, or will be described in succeeding issues of The Engineer, A. C. Wickman, Ltd., of Coventry, are showing a number of tools made in this country by the Wickman Manufacturing Company, Ltd., and the Coventry Machine Tool Works, Ltd., under licence from the foreign firms concerned. One of these tools, made by the latter of the two firms mentioned, is the Wagner cold sawing machine, illustrated in Fig. 27. This saw is driven by an electric motor hidden within the rear body and direct coupled to the lower driving shaft. It transmits its power through a belt to the driving pulley within which is situated an expanding ring clutch. The rear driving shaft on which the pulley is mounted carries sliding spur gears, by the use of which either three or four cutting speeds can be obtained, depending upon the size of the machine. From the gear-box the saw is driven through triple reduction helical gearing. All the shafts run in large bearings and are automatically lubricated by a gear pump, while the large gears dip into an oil bath. The machine is equipped with hydraulic feed, the advantages of which have been so often cited that there is no need to refer again to them here. The hydraulic medium is usually a thin fluid oil, but in a very cold shop glycerine may be used. The oil pressure is generated by a gear pump. From the pump the oil flows into a pressure and feed regulator which is controllable to give any desired pressure up to about 10 atmospheres, sufficient for the heaviest cuts. A slide valve admits the oil into the feed cylinder. To prevent the possibility of the saw being advanced too rapidly and so "digging in," the oil in front of the feed piston is only allowed to flow away through a restricted passage.

Hammer clutch hand wheels are utilised to obtain sufficient clamping of the work in the vice. These hand wheels grip the clamping spindle through two

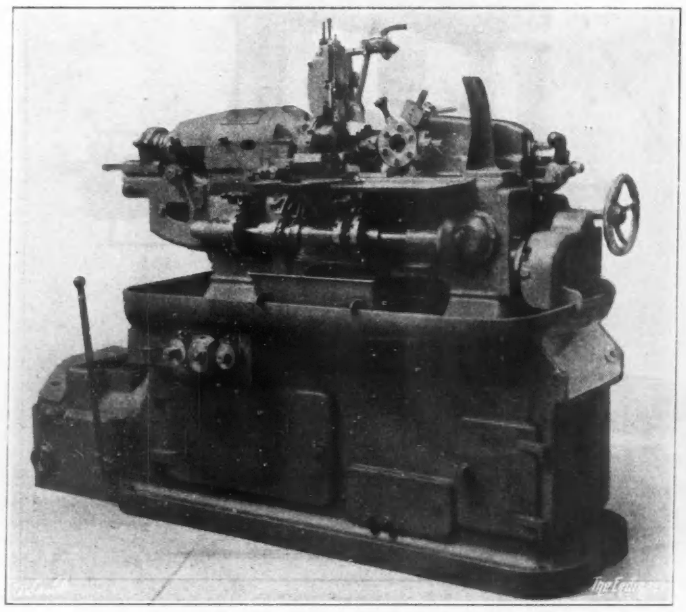


Fig. 34—1½-Inch Screw Automatic—B.S.A.

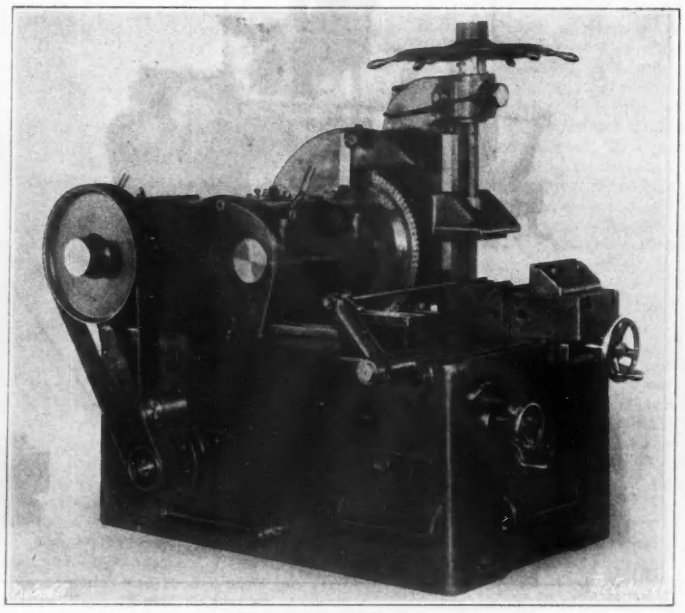


Fig. 35—Wagner Cold Sawing Machine—Wickman

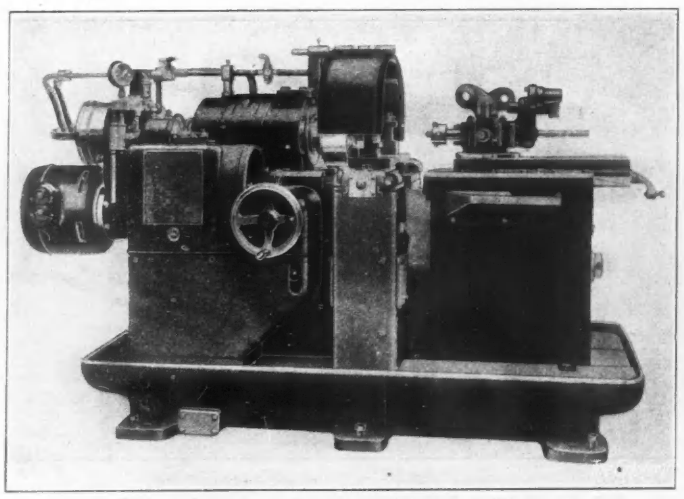


Fig. 36—9-Inch Chucking Automatic—B.S.A.

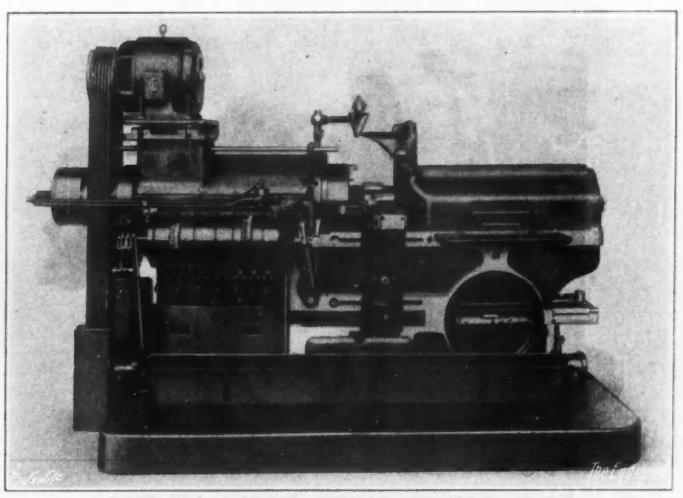


Fig. 37—Monforts Automatic—Wickman

clutch teeth and ample clearance is allowed between the back of the clutch teeth on the hand wheel and the back of the clutch teeth on the clamping spindle. So that the work may always be held at a favourable height the horizontal clamping jaw is made in two separately adjustable parts. Hydraulic clamping can be fitted to these machines if desired.

Another machine manufactured in this country by the same concern is the Forst vertical hydraulic broaching machine, illustrated in Fig. 38. It has a maximum stroke of 47in. and a peak pulling capacity of about 10 tons, and is particularly well adapted for those parts which, in the subsequent operations, are located from the hole and are of such size and weight that they can be slipped over the broach and allowed

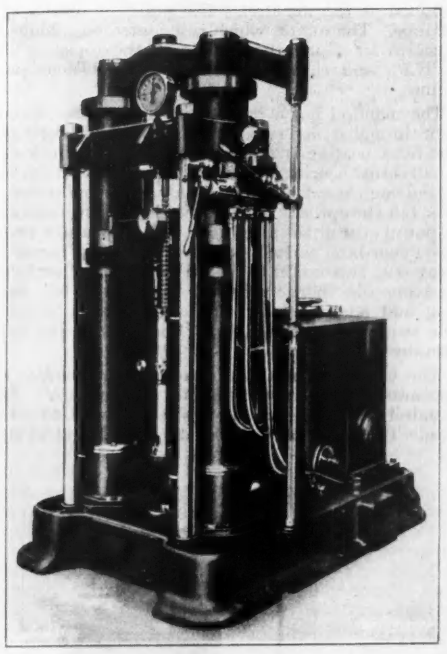


FIG. 38—FORST HYDRAULIC BROACHING MACHINE—WICKMAN

to run down a chute into a convenient receptacle. Two hydraulic cylinders are mounted on a sturdy base 13¾in. apart. The two plungers are connected by a bridge at the upper end which forms the pulling head. They are raised on the working stroke by oil pressure and move down by their own weight. Upon the pulling head there is a holder which will automatically engage the end of the broach. The latter, after a piece of work has been slipped over its top, is lifted by hydraulic means until engaged by the pulling head, which then takes charge and draws it through the work. During the broaching operation the work rests against a self-aligning locating fixture held in the cross tie of the machine. A single lever controls the sequence of movements. By its movement the broach is raised to connect with the pulling head, the broach lifting device lowers itself again and the broach passes through the work. At the end of the stroke the work is released and falls down a chute into a suitable receptacle, and the pulling head falls to the starting position and releases the broach ready for the insertion of the next work piece. As the broach is dropped a short distance when released by the head, the shock causes chips adhering to its teeth to loosen and they are easily washed away by the coolant. A pressure gauge is fitted to the machine and a safety valve may be regulated to prevent the load on the broach exceeding any predetermined figure. The machine is driven by a 15 H.P. motor running at 1500 r.p.m., which operates the hydraulic pumps and the coolant pump.

A third machine to be seen on the Wickman stand is the Monforts automatic, illustrated in Fig. 37. This machine is now made in this country by the Wickman Manufacturing Company, Ltd., of Coventry. It is designed for the use of modern cutting alloy tools. Up to twelve, or on some jobs even more, tools can be used at one time and work up to a diameter of 450 mm. can be swung. The standard turning length is 200 mm. Those interested in this class of machine should pay a visit to the stand, for in the space available in such an article as this it is only possible to mention a few of the points of interest. Ten spindle speeds are obtainable without having to use loose change gears. The feed motion to the turret and cross slide is derived from the main spindle and twelve rates of feed are obtainable. The drive is transmitted through a set of speed reducing planetary gears to a worm shaft, the worm of which drives a shaft carrying two large disc cams. Two followers, which are connected to two longitudinal slides, engage heart-shaped grooves milled into the flat surfaces of the disc cams, and by means of the oscillating movement of the slides the feed and return motion is transmitted to the turret slide and also to the cross slides. A rapid traverse motion is provided for accelerating the return of the turret and cross slides after the working feed of the tools has been finished. The turret revolves in ball bearings. Each of its faces has one large hole in the centre and two smaller holes above for carrying turning tool holders. At the end of the return stroke the turret indexes automatically. The two cross slides are independent of one another. They may be set to any angle in relation to the centre line of the main spindle.

The firm of A. C. Wickman, Ltd., is the representative in Great Britain and Ireland of Lidkopings Mek. Verkstads A/B, of Sweden, and there is exhibited on the stand one of that firm's very large centreless grinding machines of which we gave a description in our issue of Nov. 11th, 1932. The products of several other firms are also to be seen on the stand, but are described elsewhere in this Supplement or will be described in a later issue.

BURTON, GRIFFITHS AND CO., LTD.

A number of very interesting tools, both foreign and British, are to be seen on the stands taken by

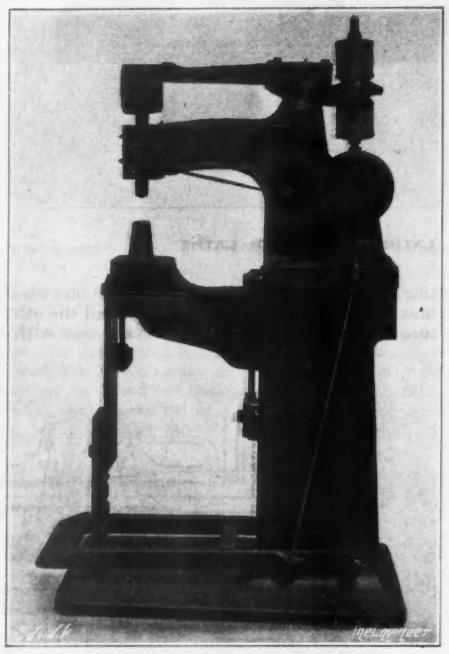


FIG. 39—HIGH-SPEED RIVETING HAMMER—BURTON, GRIFFITHS

Burton, Griffiths and Co., Ltd., of Birmingham. The tool illustrated in Fig. 39 is termed the "Rotorivet" high-speed riveting hammer, and it is claimed to reproduce very closely the resilient action of a human arm. It is, say the makers, an undisputed fact that to rivet two pieces of metal together by hand is the most successful way of performing that operation. The rivet expands properly and fills up the hole and the workman with the hammer carefully forms the

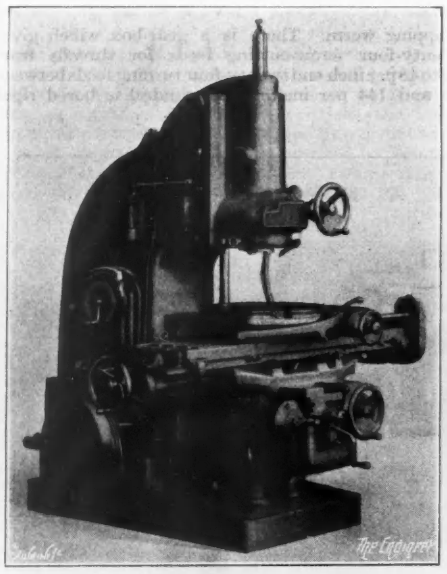


FIG. 40—KEARNEY AND TRECKER MILLER—BURTON, GRIFFITHS

head and finally cover punches it to give an improved appearance. A very satisfactorily riveted job—but a very expensive operation! It is a very important part of the riveting operation that the rivet should swell properly to fit the hole completely, and it is claimed that the "Rotorivet" hammer is so designed that this requirement is always met. The operation of the tool is very simple. It is driven by belt from a line shaft and is controlled by the pressure of the foot upon a treadle. A cam on the main driving shaft forces down an arm constructed of hickory. The cam rod is connected to the hickory arm through two large rubber cushions which, in combination with the material of the arm, give a resilience much the same as that of the hammer stave and human hand. The arm forces down on the rivet through the medium of another rubber a ram mounted in the riveting head. In the result a bouncing action instead of a pressing one is obtained, and it is claimed that in consequence the metal is caused to flow along the whole length of the rivet. The ram is driven by a worm which gives it a rotary motion and causes the metal to take up the desired shape in accordance with the design of the pein. If desired, this motion is easily disconnected. The operator sits or stands beside the machine with his foot upon the pedal. According to the pressure he exerts the oscillations per second vary, and he can rivet up two pieces either tightly or loosely according to the work the joint is required to perform. Where, for instance, a joint has to operate as a pivot, careful manipulation of the treadle will form a cup head without riveting the pieces too tightly. Although the machine is designed as a riveter, it may be used for such work as the assembling of short bushes in one or more parts and flanging them in the form of a hollow rivet or for flattening the ends of soft material. The rivet capacity of the machine is $\frac{7}{16}$in and the maximum height between the anvil and the top pein is 11in. The anvil is adjustable on a vertical slide to take work of differing thicknesses.

The Kearney and Trecker vertical milling machine, illustrated in Fig. 40, is a nicely designed tool. It has a table working surface of 56in. by 12in. Twenty-seven speed changes from 15 to 1500 r.p.m. are available. The higher speeds are obtained through a silent worm drive, and a heavy bull gear takes care of the lower speeds. Surface speeds up to 100ft. a minute can be used. The range of feeds extends from 40in. to 60in. per minute in twenty-seven steps. Changes are made by the use of a single control handle and dial at the front of the machine. The spindle is under the control of a four-position micrometer stop and dial indicator, which makes it possible to locate the spindle quickly and accurately for all step cut operations. The tool is shown machining castings which have surfaces to be milled on different sides so that step milling can be demonstrated. The following table gives some particulars:—

Table working surface	56in. by 12in.
Power feed	28in.
Cross power feed	28in.
Vertical power feed	14in.
Speeds	27, 15 to 1500 with reverse
Feeds	27, ½in. to 60in.
Feeds, vertical	¼in. to 30in.
Power feeds to head (extra)	27, ¼in. to 30in.
Spindle to table top	0 to 15⅝ in.
Speeds	27, 15 to 1500 r.p.m. with reverse
Feeds	27, ½in. to 60in.
Feeds, vertical	27, ¼in. to 30in.

There are numerous other machines on the stands, which we hope to describe further at a later date.

MASCHINENFABRIK LORENZ A.-G.

The gear cutter illustrated in Fig. 41 is a product of Maschinenfabrik Lorenz A.-G., of Karlsruhe, Germany, for which A. C. Wickman, Ltd., is the sole agent in this country. It is to be seen on the stand taken by A. C. Wickman, Ltd., and, as will be observed from the engraving, is of the type in which

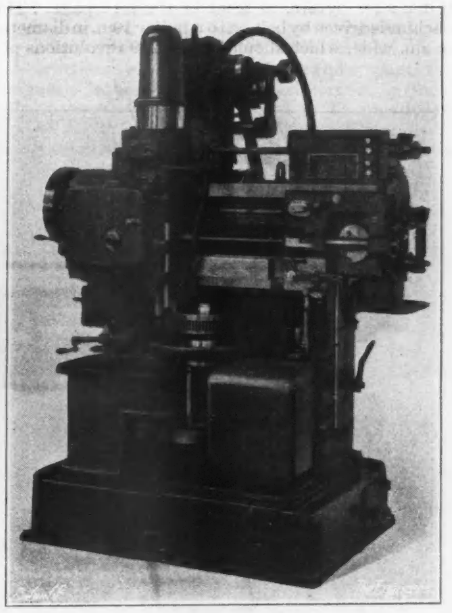


FIG. 41—GEAR CUTTER—LORENZ

a pinion-shaped cutter is given a vertical reciprocating motion and generates the required tooth in the gear blank as the rotation of tool and work takes place. It will take work up to 450 mm. in diameter, and generate teeth up to a width of 75 mm. The machine is driven through a belt from an electric motor.

From the main driving shaft the power is transmitted through a six-speed gear-box to the ram spindle, *viâ* a disc crank, connecting-rod, and a tooth segment lever. The infeed of the carriage is controlled by a cam, which is driven directly from the ram drive, but is independent of the rotary feed. At the completion of a predetermined infeed the drive of the cam is automatically stopped and the rotary feed begins. When the cutting cycle is completed the carriage recedes from the work and the machine stops. Removal of the finished gear and the insertion of a new blank is made easy by the fact that the work spindle and its mechanism is arranged to swing outwards to a convenient position. A relief motion to prevent the cutter fouling the work on the up stroke is operated by a long knee lever actuated by a cam. The cutters used are 4in. in diameter by 1¾in. bore.

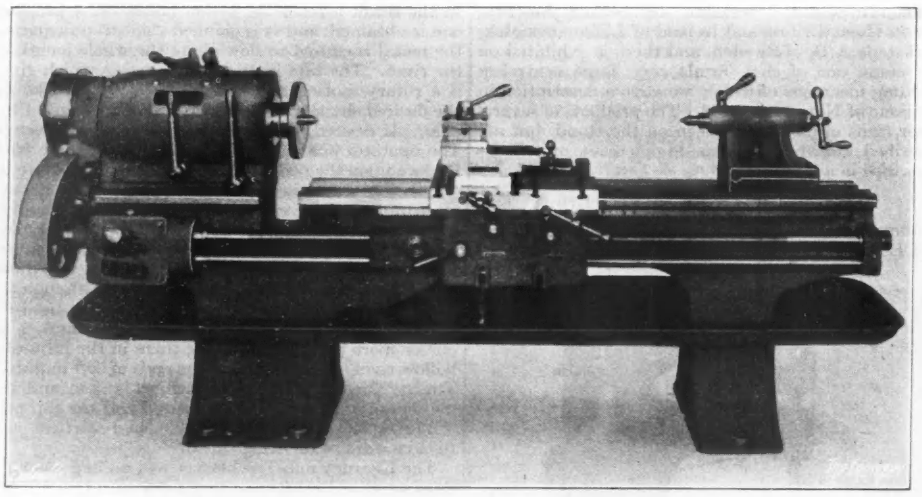


FIG. 42—8½-INCH "ALL GEARED" LATHE—COLCHESTER LATHE

THE COLCHESTER LATHE COMPANY.

On the stand of the Colchester Lathe Company, Hythe, Colchester, the most novel exhibits are three lathes of the "All-Geared" head type, two of which are illustrated by Figs. 42 and 43. These machines have centre heights of 6in., 7in., and 8½in., and are each connected with a countershaft or with an electric motor by a belt running on a single pulley. The change in rotational speed necessary to accommodate the work in hand is effected by sliding gears in the headstock and cone pulleys are avoided. There are, however, a number of lathes of more, shall we say, "old-fashioned" design, with cone pulleys and back gear, for those who do not desire elaboration.

The largest of the three all-geared lathes, the front elevation of which is shown in Fig. 42, has a height of 8½in. at the centres and will swing work 12in. in diameter over the saddle. With a normal 8ft. bed it will take 4ft. 6in. between the centres, but this length can be extended to 8ft. 6in. by means of special beds. The swing within the full gap is 28in. in diameter by 8in. in front of the face plate. The machine is driven by belt on to a pulley 10in. in diameter by 8in. wide, which should run at 250 revolutions per minute, and thence through a friction clutch, and a train of sliding toothed gears, that give a range of eight speeds from 15 to 255 revolutions per minute. The arrangement of this gearing is illustrated in Fig. 44 in connection with the 7in. centres lathe. When the lathe has an independent electric drive the motor is mounted on a bracket, at the back, which allows the tension in the Vee belt to be adjusted. There are two methods of feeding the slide rest along, one, for screw cutting, by means of a lead screw cut from one whose accuracy is vouched for by the N.P.L., and the other by means of a splined shaft, which is engaged with a dropping worm. There is a gear-box which gives twenty-four screw-cutting feeds for threads from 3½ to 48 per inch and twenty-four turning feeds between 10 and 144 per inch. The mandrel is bored right through, 2 1/16in. in diameter, and runs in a front bearing 3⅞in. in diameter by 4½in. long. The end thrust is taken on a ball bearing.

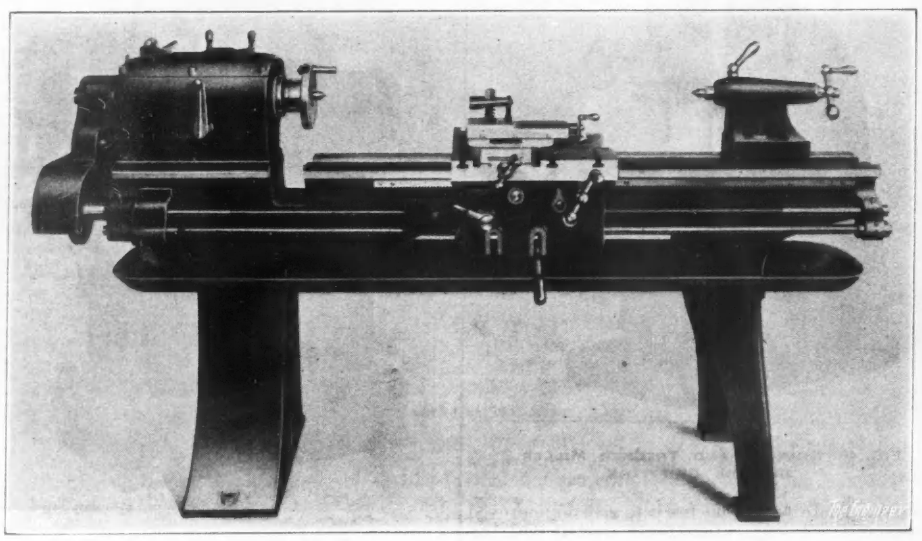


FIG. 43—7-INCH "ALL GEARED" LATHE—COLCHESTER LATHE

The 7in. lathe—see Fig. 43—has many characteristics similar to those of the machine just described and also has an all-geared headstock. We give a plan view drawing of this gearing in Fig. 44. It will be seen that the drive is transmitted from the fast-and-loose belt pulley—in the case of the electric drive the loose pulley is omitted—through an intermediate shaft to the mandrel. A set of sliding gears on the first shaft, operated by two handles on the top of the headstock, provides four ratios of gear at the intermediate shaft. These are multiplied by two for transmission to the mandrel. There are thus eight speeds in geometrical progression from 30 to 340 revolutions per minute. In the case of the motor-driven lathe—Fig. 45—the pulley is fitted with a clutch and runs at 575 revolutions per minute, while speeds from 20 to 390 revolutions per minute are obtained at the mandrel. The pulley is driven by Texrope. The motor, which is mounted on a hinged platform to adjust the tension in the ropes, is of 1¼ H.P., and runs at about 1400 revolutions per minute.

The mandrel has a hole 1 5/16in. in diameter bored right through it, and runs in phosphor bronze bearings. The front bearing is 2½in. in diameter by 3½in. long. A ball thrust bearing is fitted. Besides the lead screw, for cutting threads there is a shaft for giving turning cuts, but the apron is so arranged that the two cannot be put in gear at the same time. There is also a two-speed gear-box, and no matter what pitch of screw is being cut, two useful feeds can be obtained without resetting the change wheels. The bed is 6ft. 6in. long and admits pieces 4ft. long between centres. The swing over the saddle is 10in. and in the gap 21in. by 5in.

The 6in. lathe, not illustrated, is very similar in appearance and construction to the 7in. size. Its mandrel is bored 1¼in., and it will take work 3ft. 2in. long. The swing over the saddle is 9in., and in the gap 18in. by 4½in. It requires a motor of about ¾ horse-power.

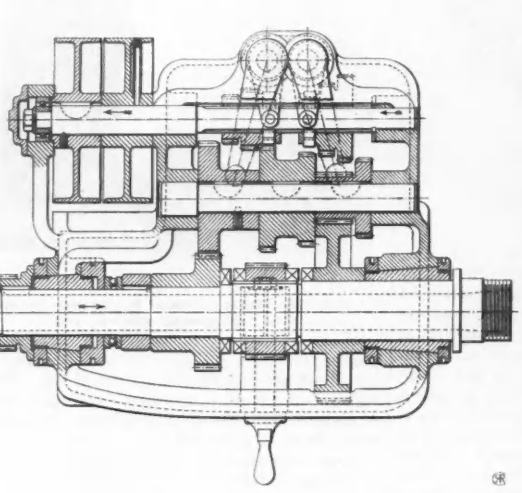


FIG. 44—GEAR-BOX OF 7-INCH LATHE

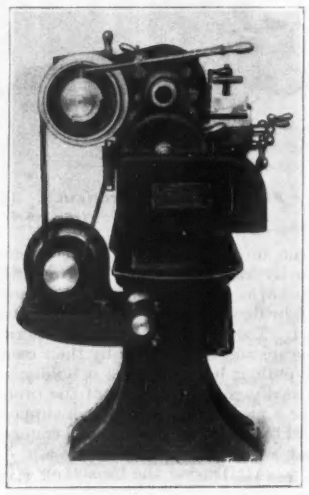


FIG. 45—ARRANGEMENT OF INDIVIDUAL MOTOR DRIVE

THE RENOLD AND COVENTRY CHAIN COMPANY, LTD.

A visitor to the Exhibition can observe many examples of chain driving by means of Renold chains incorporated in the machines shown by other exhibitors, but this firm, whose works are at Didsbury, near Manchester, has its own stand, where special applications of the chain are illustrated. The block, roller, and tooth chains of the company are so familiar to engineers that they need no description here, but there are some new applications, in the form of chain couplings which maintain the 98½ per cent. efficiency of the chain drive and permit slight irregularities in shaft alignment and parallelism through the flexibility of the chain. There are also some examples of the Renold-Hardy flexible coupling, which is specially applicable to cases where impulsive loads have to be transmitted.

A comparative novelty is the Renold push-pull remote control for transmitting an impulse from one point to another where the intervening route may have many corners. Among such services may be included the opening and closing of fanlights and dampers, the operation of engine-room telegraphs, and so forth. The idea is to encase a specially designed roller chain in a closely fitting solid-drawn steel tube, which can be bent or adapted by special fittings to any contour. The chain is practically inextendable and non-compressible, and so transmits movement from end to end unimpaired. Where long straight runs are met, a plain connecting-rod is used in place of the chain. Various standardised fittings have been designed, both for the tubing and for the ends of the chain to adapt the idea to many requirements without the use of special tools.

JOHN LUND, LTD.

For those interested in grinding machines of the cylindrical and surface types, there is an excellent

show on the stand of John Lund, Ltd., of Crosshills, near Keighley. As grinding is a particularly accurate operation, it is above all things, important that the beds of grinding machines should be strong, and, if not heavy, at least so designed with strengthening ribs that vibration shall be resisted. This point is well understood by the firm, and although in the illustrations the details of the design of the beds of the machines cannot be observed, enough is visible to indicate that they are sturdily constructed. The cylindrical grinding machine illustrated in Fig. 46 has been designed to be capable of rapid and accurate production without at the same time being too elaborate. It is made in two sizes, both of which are shown on the stand. One has a normal grinding length of 36in., and the other one of 24in, both on a maximum diameter of 6in. Normally, the grinding wheel supplied is 20in. in diameter by 2in. wide, but by the use of special flanges and a wheel guard extension, wheels up to 4in. wide can be fitted. The wheel is mounted on a large diameter nitralloy spindle running in long phosphor bronze alloy bearings, and the spindle is driven by electric motor through triple V belts. The feed of the wheel head is operated by the table-reversing mechanism, and can be varied from 0·0001in. to 0·001in. in increments of 0·0001in. A ½ H.P. motor with a speed range between 40 and 400 r.p.m. drives the work headstock. It takes its current from a generator mounted on the bed at the rear of the machine, and driven by a "V" belt from the main drive shaft. The table traverse is operated hydraulically, and is controlled by a start and stop lever on the front of the bed. Any speed between 6in. and 240in. per minute is available, and is obtained by the use of a conveniently placed knob. There is also a hand table traverse, which can be readily engaged when required.

The other machine, illustrated in Fig. 47, is a vertical spindle surface grinder. It is one of a range of similar machines, all with grinding lengths of 48in., but with widths of 12in., 16in., and 18in., and heights of 12in., 16in., and 18in. respectively. The diameters of the wheels on these three machines are respectively 14in., 18in., and 24in. The wheels are of the segmental type. The spindle is carried in large-diameter preloaded ball bearings, and is driven by an electric motor unit made and mounted as an integral part of the grinding head. Two flat slides of the narrow guide type carry the grinding head and a 1 H.P. reversing motor controlled by "press to run" buttons rapidly raises or lowers it to suit the thickness of the work. The table motion is operated from a hydraulic cylinder mounted in the main body of the machine, and can be traversed at any speed between 1ft. and 35ft. per minute. To maintain consistency of table traverse rate the oil travelling in the circuit is water cooled. The down feed of the grinding wheel is also hydraulically controlled, and a range of feeds between 0·00025 and 0·004 is available at either or both ends of the table stroke.

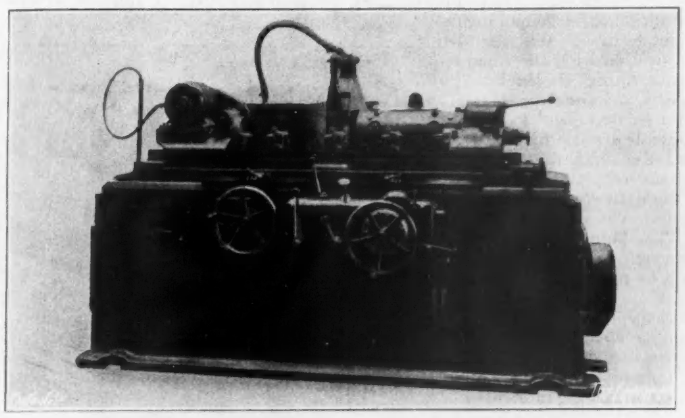


FIG. 46—CYLINDRICAL GRINDING MACHINE—LUND

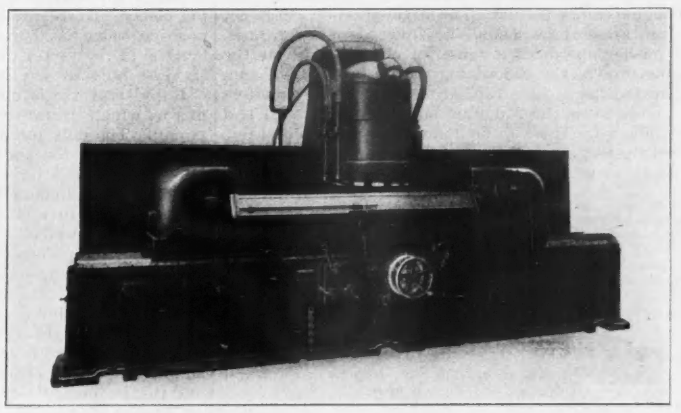


FIG. 47—VERTICAL SPINDLE SURFACE GRINDER—LUND

DEAN, SMITH AND GRACE, LTD.

If length of ancestral lineage counts for anything among machine tools then the lathe must be placed among the aristocrats. Nowadays, of course, it has fallen from its former high estate in that many of the functions it can perform are more rapidly carried out on specialist machines. But it remains, nevertheless, the one essential tool without which no workshop can be complete. We speak, of course, of the ordinary centre lathe and not of the variety of more specialised types that have developed from it. A number of typical machines are to be seen on the stand of Dean, Smith and Grace, of Keighley, and in Figs. 48, 49, and 50 we illustrate some of the products of the firm. The 8½in. high-speed lathe—Fig. 49—is a particularly neatly designed machine. As will be inferred from the engraving, it is driven by an electric motor bolted low down on to one end of the bed. Push buttons mounted on the fast headstock control the motor, which may be for either A.C. or D.C. current, and which runs at 1450 r.p.m., giving 13¼ H.P. The actual starter itself is enclosed within the bed, and the door which gives access to it cannot be opened without first opening the contacts of an ironclad isolating switch. As the motor drives the lathe through a multiplate clutch operated by a lever at the front of the headstock, there is no need to stop the motor when the lathe is stopped. Twelve spindle speeds from 602 to 27 r.p.m. are available. They are obtained by the use of chrome nickel steel gears mounted in a gear-box situated below the spindle and within the bed. These gears are constantly lubricated by oil flowing from a trough above, supplied by a small pump from below. Except for the spindle, which is carried in parallel bearings, all the shafts run in ball bearings. The spindle is bored with a 3⅝in. hole and has a large collar to which chucks and face plates can be bolted.

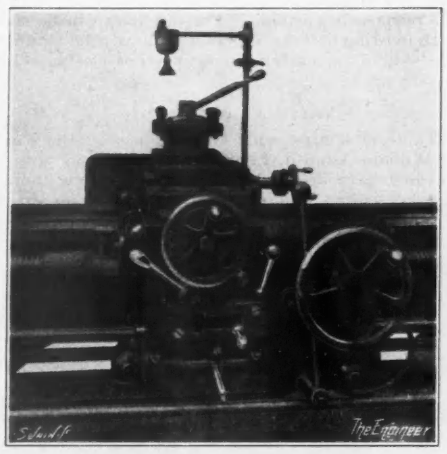


FIG. 48—SADDLE OF 8½-INCH LATHE—DEAN, SMITH

The arrangement of the saddle can be observed from the separate illustration, Fig. 48. It is carried on large bearing surfaces, and has a narrow guide at the front. There is a taper gib for taking up wear. A gear-box in the apron gives four rates of feed and also controls the screw threads cut in groups of four. The group is altered by the use of change wheels carried on a swing plate on the box and enclosed by a cover. As will be inferred from the engraving, a single handle controls the surfacing and sliding feeds, so that it is impossible to have both feeds in operation at the same time. Nor can the screw-cutting feed be engaged when either of the other feeds is in operation.

The lead screw is the heart and soul of a screw-cutting lathe. Dean, Smith and Grace, Ltd., have paid particular attention to the manufacture and mounting of this component, and the firm is willing to guarantee that the limits of error do not exceed +0·002in. or −0·003in. in a length of 6ft., and that in any foot they will not exceed ±0·001in. These measurements, it should be noted, are taken at the tool point of the finished lathe, and therefore take into account possible errors in the mounting of the screw. The machine is built with a standard length of bed of 10ft., and admits between centres work 5ft. 6½in. long. Its swing over the bed is 17½in. and in the gap 30½in. diameter by 10¾in. wide.

A 6½in. all-geared head lathe exhibited on the same stand is illustrated by Fig. 50. The general design of the bed and saddle is very similar to that of the machine just described. But there are considerable differences in the headstock. The hollow spindle is carried at the front neck in two roller bearings, and at the back neck by two combined radial and thrust bearings. In addition to the usual threaded nose the spindle has a large flange to which chucks and face plates may be bolted. The spindle is driven through either of two gears, which give a high and a low range of speeds respectively. Each range consists of nine speeds, the total range covering speeds between 23·7 and 761 r.p.m. The speed change levers are grouped near the front end of the headstock, and close to the stop-start lever. The latter, it should be noted, is duplicated alongside the saddle. It operates a powerful friction disc clutch when starting and a brake when stopping. The machine exhibited is driven through V ropes from a 5 H.P. motor mounted behind the bed.

THOMAS RYDER AND SON, LTD.

A vertical single-spindle three-slide multi-tool automatic lathe with push button control, giving a fully automatic cycle, is exhibited by Thomas Ryder and Son, Ltd., of Turner Bridge Works, Bolton. The specification for the machine—Fig. 51—which is known as the No. 12 Rydermatic, is given on page 14.

The advantages claimed for the vertical construction are mobility of the machine and great saving of floor space. Heavy parts can easily be loaded. The chips fall clear and do not clog the tools and slides. Excentric parts do not require balancing and a greater overhang can be used without loss of rigidity. All controls are within easy reach of the operator. Flood lubrication to all parts of the machine is possible with a very simple lay-out and with the use of a single pump.

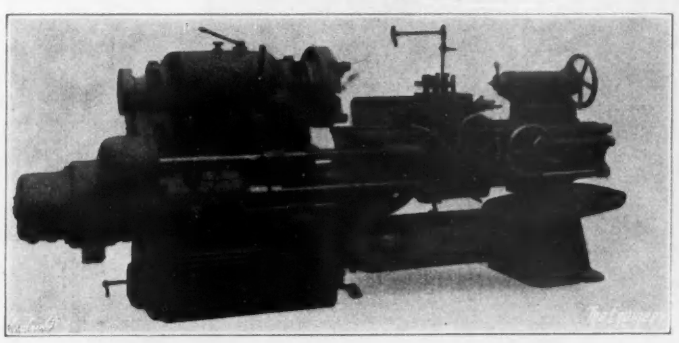


FIG. 49—8½-INCH HIGH-SPEED LATHE—DEAN, SMITH

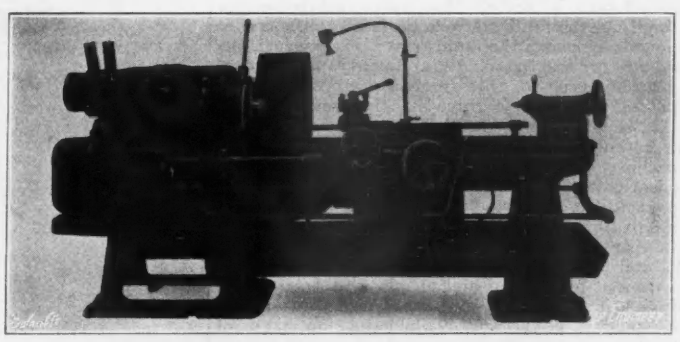


FIG. 50—6½-INCH "ALL-GEARED" LATHE—DEAN, SMITH

The main spindle is mounted on special precision ball and roller bearings with predetermined loading. Ball and roller bearings are also used for every high-speed bearing on the machine, the loose headstock spindle being fitted with a ball and roller bearing centre. All worms are case-hardened and ground on the threads and the worm wheels are composed of phosphor-bronze. The turning slide is provided with full rectangular motion, which, if required, can be converted to straight or former-operated motion. No return traverse marks are left and diameters between flanges of any length within the capacity of the machine can be turned. The auxiliary slide can be set at any angle and will cut either upwards or downwards. If pusher operated, it must, of course, finish at the same time as the slide doing the pushing, but if cam operated it can be arranged to finish skim diameters or faces after the roughing slides have finished and withdrawn. This can be done at high speed and fine feed by the use of the two-speed mechanism in the spindle drive.

Swing	15in. maximum
Length between centres	16in. with standard machine
Clearance length above chuck face	Up to 3ft.
Turning slide stroke, vertical	8in.
Facing slide stroke, horizontal	5½in.
Auxiliary slide stroke at any angle	4in.
Floor space	4ft. 6in. wide 6ft. 6in. deep with chip container 5ft. 3in. deep for use with chip conveyor
Speed range	30–610 r.p.m.
Feed range	23–400 cuts per inch
Spindle flange	8in. diameter
Spindle bore	1⅞in. diameter
Morse taper of spindle nose	No. 5

After loading the chuck or placing work between the centres the operator pushes the "start rapid traverse"

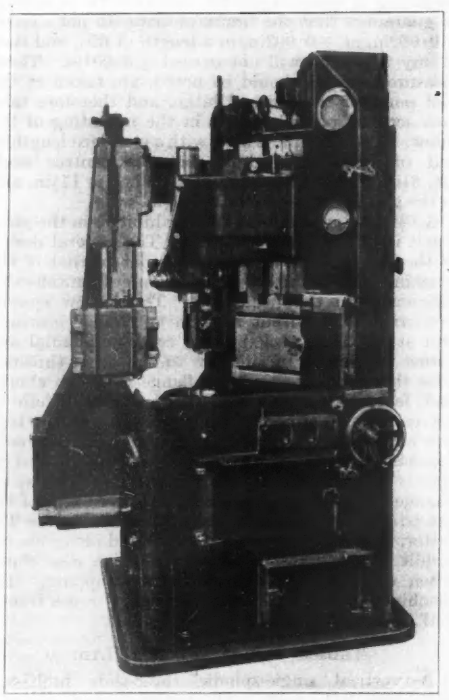


FIG. 51—VERTICAL AUTOMATIC—RYDER

button and the operation is then automatic. The main motor is started, the rapid traverse motion stops, and the feeding stroke begins. At the end of the cutting stroke the rapid traverse is engaged, the slides return and the spindle is brought rapidly to rest.

Various types of these tools are supplied, viz., a two-slide machine, a three-slide machine with the third slide pusher operated, or a three-slide machine with the third slide cam operated. Any of these machines can be supplied with the two-speed mechanism to the spindle and with a mechanical or air-operated loose headstock or chuck. The main motor of 8 to 10 H.P. is housed in an open compartment at the rear of the machine, the drive being taken by a Fabroil pinion and large single helical gears to the two-speed mechanism and change wheels, the final drive being through a worm and wheel. Two ranges of spindle speeds are available—a low-speed of 30–305 r.p.m. and a high-speed of 60–610 r.p.m., giving a total range of 30–610 r.p.m. Any speed in one range can be automatically changed by means of a clutch to a speed in the other range at any time during the running cycle. The ratio of the change is determined by a separate pair of change wheels and can be varied up to a maximum of 4 to 1. In addition to the automatic "start" and "stop" feature, the spindle can be hand controlled by a push button and an automatic brake is incorporated.

The main turning and facing slides are fed by hardened steel cams and the auxiliary slide may be either cam or pusher operated, changes of feed being obtained by means of change wheels. Variations of feed ratio between the turning and facing slides is obtained by changing the facing slide cam. Special cams for different lengths of stroke are unnecessary, and the full movement of all slides can be used. All change wheels for speed feed and the two-speed automatic clutch are behind a hinged door in front of the operator, while spare change wheels are accommodated in a compartment at the base of the machine.

When the machine is set for automatic operation the feed lever remains in the "power feed" position. When it is required to control the slides quickly by power when setting up the machine, the lever must be placed in the neutral position, the remaining position being used when hand feeding. When the lever is in the power or hand feed position the rapid traverse buttons are inoperative during the cycle.

Rapid traverse is obtained by a separate electric motor, which drives through a single helical Fabroil pinion. The only manual controls are the four push buttons: two for controlling the main motor and two controlling the main traverse, the "start" rapid traverse button being used to start the automatic cycle. In addition, there are a feed control lever and a hand feed wheel. The automatic controls are operated by dogs on the vertical cam drum and can be set to operate the tappets at any point in the cycle.

As regards the flood lubrication system, oil is pumped to a sight-feed chamber at the top of the machine and is led from this point to all the bearings, slides, gears, &c. The main spindle, auxiliary slide, and turning cross slide are, however, grease lubricated by means of a grease gun. Apart from occasional attention to the Fabroil motor pinions, no other oiling is necessary. For supplying the cutting lubricant a motor-driven suds pump is fitted and is wired in conjunction with the main motor so that it is automatically put out of action when the spindle stops. A separate cut-out switch enables the machine to be tooled up without interfering with the cutting lubricant. Together with the cutting lubricant, the cuttings pass down a chute at the rear of the machine and removable guards facilitate chip removal. The large filter with gauze on the underside can be taken out through an opening at the side of the machine for the purpose of cleaning. The machines can be used with existing systems of swarf removal, the chute in the body of the machine being lipped to overhang chip conveyors.

WILLIAM ASQUITH, LTD.

There is a large range of machines on the stand of William Asquith, Ltd., Halifax, England, several of which have already been described in our columns; the keyseating and cotterway machines shown in Figs. 52 and 53 are, however, comparatively new.

The keyseating machine—see Fig. 52—will cut keyways up to ¾in. wide by 6in. long, in shafts with a maximum diameter of 3in. It has, it will be seen, two opposed heads, and is of the type in which a revolving end mill is reciprocated along the length of the keyseat, removing a light cut at each traverse. In this way a good true seat can be obtained with an overhung cutter and with a minimum of offset at the ends of the cut. The horizontal arrangement of the cutter spindles also ensures that the swarf will fall clear of the cut and will not clog the tool, as is sometimes the case when a vertical mill is used. The cutters are held in spring collet chucks on the spindles and can be run at three speeds—400, 700, and 1200 r.p.m. The spindles have independent hand adjustments, or may be fed simultaneously by power. The depth of the cut is stopped automatically, and when cotterways are being cut, one head is stopped slightly before the other. The thin wall of metal in the centre of the shaft is then cut away by the other cutter. The first cutter is, of course, first backed out. Alternatively the tripping point can be made the same for both heads, when it is desired to mill out splines or

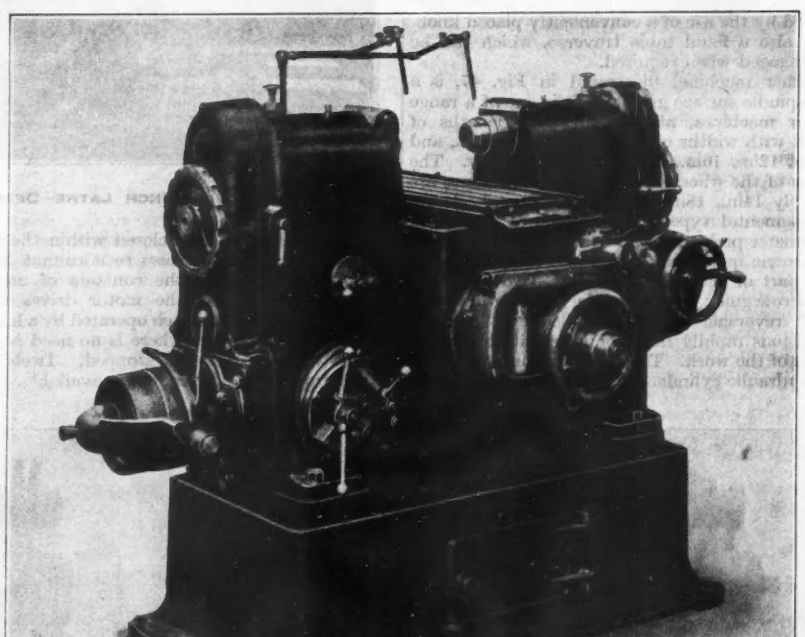


FIG. 52—KEYSEATING MACHINE—ASQUITH

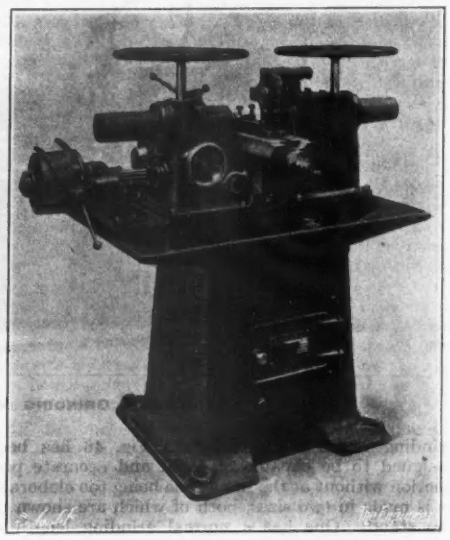


FIG. 53—COTTERWAY MACHINE—ASQUITH

pairs of keyways at 180 deg. The amount of the infeed of the cutter at each traverse is adjustable within wide limits by means of a ratchet motion. The length of the keyway is determined by the setting of an adjustable crank arm, but the speed of travel is maintained practically constant throughout the stroke by means of a drum cam. The connecting-rod can be easily adjusted at the crosshead end to fix the position of the table and save the fine adjustment of the workpiece in its fixture. Sufficient length of bed is provided to support the work table without objectionable overhang at the end of the stroke. The table, by the way, has an area of 24in. by 7in., and the machine requires about 4 horse-power.

In the case of the machine shown in Fig. 53, a different process is adopted, as it is intended for cutting cotterways right through shafts and rods. It has, it will be seen, two heads. The right-hand head carries a drilling spindle, and the opposite head a milling spindle; three speed changes are provided for the two spindles, which are driven jointly. A rotating steady bracket on the right-hand head, located by a plunger and fitted with interchangeable case-hardened bushes, is used to support the drill for

the first operation, and then to carry the outer end of the milling cutter for the second operation. The method of procedure is first to advance the drill through the appropriate bush until a hole is pierced completely through the shaft, using the large hand wheel on the right-hand head for this purpose. After withdrawing the drill, the steady bracket is rotated 90 deg. to align the smaller bush used for supporting the outer end of the milling cutter. This cutter is carried by the left-hand spindle and is fed forward by the left-hand wheel through the drilled hole until its outer end is fully supported in the steady bush. The spindle barrel is then locked in this position, and power feed is applied to the table which is traversed to give the required length of cotterway. A crank disc with adjustable throw and a graduated scale controls the length of the cotterway, and means are provided by screw adjustment of the connecting-rod for setting the workpiece to give the position of the cotterway. The rate of table reciprocation is altered by changing slip gears housed at the rear of the machine.

Among the drilling machines to be seen on this stand there is the 6ft. radial drill illustrated by Fig. 54. The pillar of this machine has two diameters, which eliminates a loose sleeve and makes a rigid structure. The arm is raised and lowered upon it by means of a separate motor mounted on the top, which is provided with stops to prevent over-running. Roller bearings at the top and bottom of the bell section enable the arm to be easily swung round the column. The motor for driving the drill, and all the working controls are arranged on the spindle slide, and the latter are grouped together

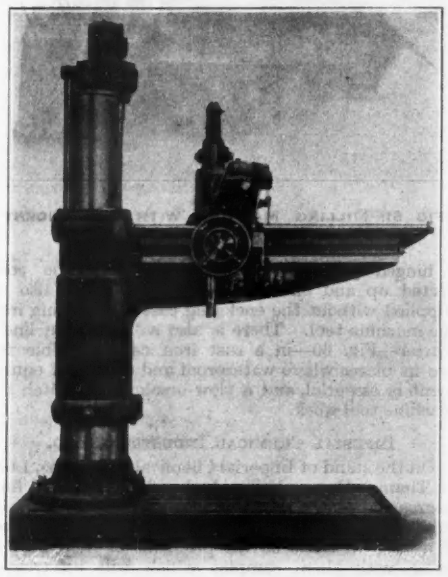


Fig. 54—Radial Drill—Asquith

within an area of 15in. by 23in., so that the attendant has no need to move about at his work. The weight of the slide is carried on ball-bearing rollers, and it is traversed, by hand, by means of a chain and pinion. Twelve speeds are provided through a six-speed gear-box and double gear, together with four rates of self-acting feed motion. There are also fine hand feed and quick spindle adjustments by means of conveniently placed hand wheels. The self-acting feed to the spindle is put into action by bringing the drill point into contact with the work and giving the hand wheel a slight further movement. Reverse movement of the same hand wheel disengages the feed and withdraws the spindle. Reverse to the spindle is obtained electrically, thus eliminating troubles experienced with many forms of mechanical clutches. An automatic depth stop is provided with an indexed dial.

The machine will drill to within a radius of 1ft. 6in. and take pieces up to 5ft. high under the spindle nose. The spindle is bored No. 5 Morse taper.

Holbrook Machine Tool Company, Ltd.

There are three lathes on the stand of the Holbrook Machine Tool Company, Ltd., 44–48, Martin-street, Stratford, London, E.15, all of which have the general appearance of the machine illustrated in Fig. 55. They are capable of swinging over the bed, pieces 13in., 17in., and 21in. in diameter, respectively, with corresponding lengths of 36in., 42in., and 48in. There are also several other lathes, which we do not illustrate.

The No. 21B lathe has a headstock of the single pulley type, which gives sixteen speeds for the mandrel. The speeds range from 8 to 408 r.p.m. with the driving pulley running at 600 r.p.m., and the one required is obtained by manipulating the levers on the front. The first drive gear-box is bolted directly to the lathe bed, so as to remove the initial driving strains from the headstock, and the final driving pinion is mounted close up to the front end of the mandrel to reduce torsional stresses. All the shafts in the headstock run in roller bearings, not ball bearings, and those at the front end of the mandrel, which are 7½in. in diameter, are of the pre-loaded Timken type. That is to say, the two rings of rollers are securely clamped together to take end thrust in either direction without movement. The bearing at the tail end of the mandrel is free to take up expansion and contraction caused by temperature variations. The spindle is hardened and ground all over and has a flange at the front on to which the chucks are bolted. This flange has a tapered spigot for centring

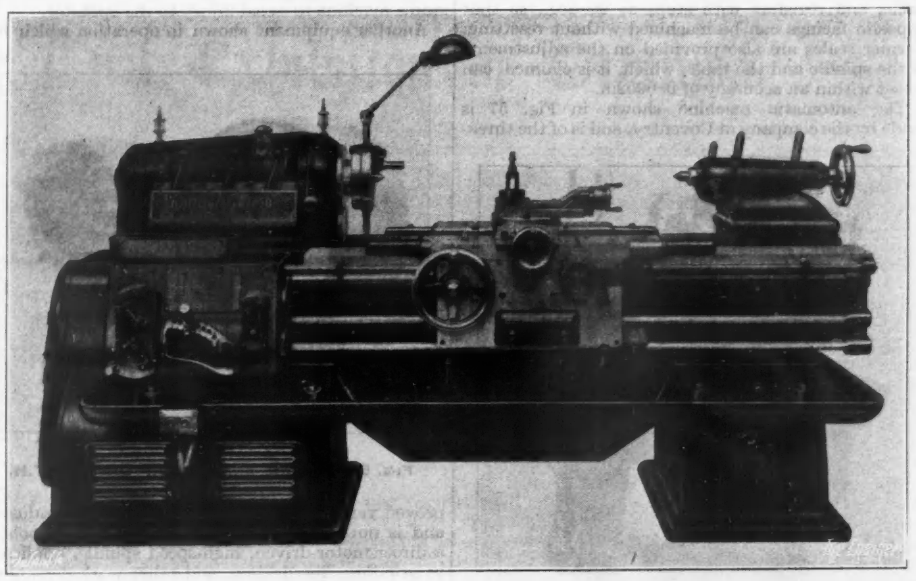


Fig. 55—Precision Tool-Room Lathe—Holbrook

the chucks and the added advantage of strengthening up the nose where the taper bore for the centre is made. There is a 2in. hole bored through the mandrel and the taper for the centre is No. 4 Morse. The flange is 11in. in diameter. The gearing is of nickel-chrome steel, hardened and ground on the generating principle on Maag grinding machines. The angle of pressure between the teeth is limited to 20 deg. The direction of rotation of the mandrel, at all speeds, can be reversed by levers on the headstock and the apron.

The tailstock runs on V guides separate from the flats for the saddle, and can be set over on its base. The barrel is convenient for taking drills and has a ball thrust washer. The lead screw and the feed shaft are driven from a gear-box, which can be seen in front of and below the headstock. This box gives sixty changes from one to fifty-six threads per inch directly and, with the addition of a removable quadrant box, provides for metric and bastard threads. The feeds for sliding and surfacing range from 0·003in. to 0·1667in. The lead screw is 1¾in. in diameter and has two threads per inch. These screws are cut from a special grade of steel and are allowed to mature for about three months before they are finished on a machine, the lead screw of which was reproduced from an N.P.L. master and is equipped with a correcting bar. The thrust of the lead screw on the lathe is taken by washers with spherical seatings that eliminate end thrust. The saddle is guided by a front raised V and a flat on the bed and has a length along the V of 35¼in. It has a taper turning arrangement and the top slide will swivel right round the circle. The sliding and surfacing feeds are engaged instantaneously by finger tip controls and there is a quick pull out on the cross slide for use when cutting threads. Ball thrust washers and roller bearings are used wherever it has been considered necessary. There are safety devices in both feeds, and micrometer dials reading to 0·001in. on both the surfacing and top slide screws. The machine requires about 7½ H.P.

Among the other lathes exhibited on this stand there are some for high-speed turning with tungsten carbide tools and diamond finish turning. These include a 6in. centre lathe with a geared head-stock that provides spindle speeds of from 30 to 1500 r.p.m.; another, smaller, one which turns and faces to a dead stop, and can be run as fast as 2500 r.p.m.; and an "electric-hydraulic 'Quick-Cut' lathe." A three-speed change-pole motor is used to drive the 6in. lathe just mentioned.

Modern Machine Tools, Ltd.

The works of Modern Machine Tools, Ltd., at the Butts, Coventry, are largely employed in the rebuilding of machine tools, the manufacture of pumps, and in dealing with machines of foreign manufacture,

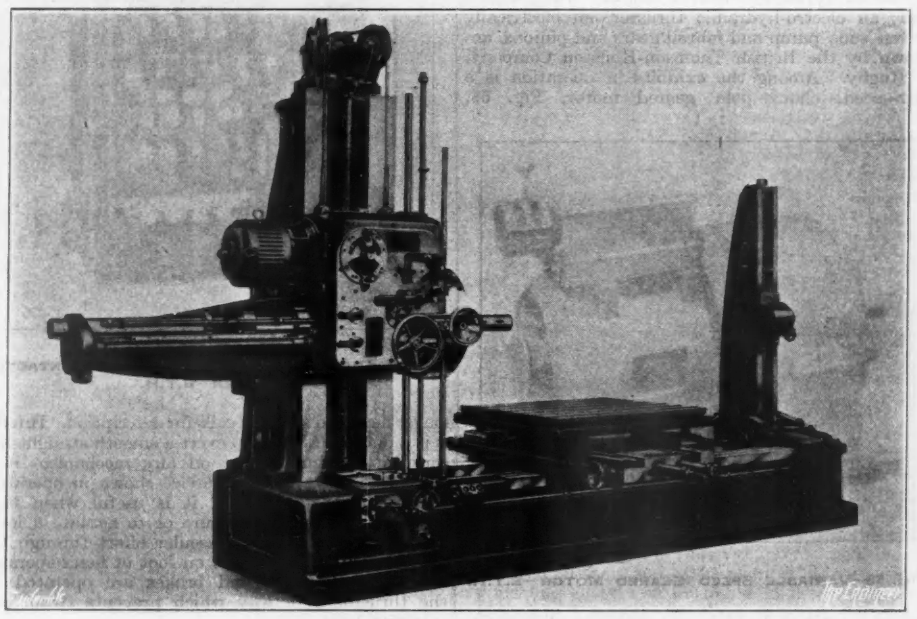


Fig. 56—Horizontal Boring and Milling Machine—Modern Machine Tools

and an assortment of machines is exhibited on the firm's stand. We illustrate two in Figs. 56 and 57.

The horizontal boring and milling machine—see Fig. 56—is made in five sizes, with spindles ranging from 2¾in. up to 5¼in. diameter. The driving motor, it will be seen, is mounted on the saddle and drives all the motions through the minimum of gearing, so as to save power transmission losses. It is noteworthy that there are no bevel gears, and that all the high-speed shafts run in either ball or roller

bearings. Gearing is provided for giving eighteen different speeds to the boring spindle, which range from 12 to 600 r.p.m. in the case of the smallest machine, and from 4·8 to 240 revolutions in the largest size. As many as forty-two different speeds of boring feed can also be obtained. A rapid traverse motion, with a speed of 6½in. per minute, is provided, and when it is in use the hand wheel is disconnected so that it does not revolve at a dangerous speed. Adjustable automatic stops are provided for all the various feeds, including those of the table. The table, by the way, can be rotated through a complete circle, and registers with stops at 90 deg., so that opposite facings can be machined without resetting. Vernier scales are also provided on the adjustments of the spindle and the table, which, it is claimed, can be set within an accuracy of 0·0002in.

The automatic machine shown in Fig. 57 is made by the company at Coventry, and is of the three-

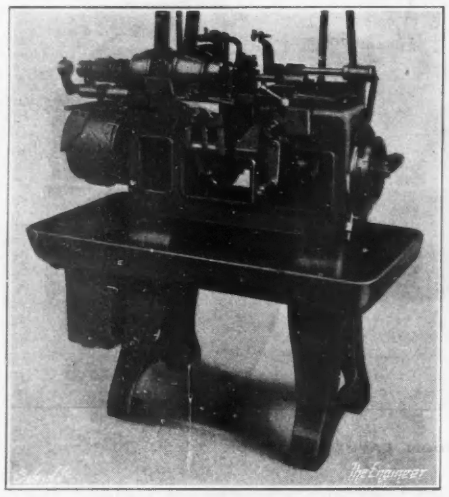


FIG. 57—THREE-OPERATION AUTOMATIC—MODERN MACHINE TOOLS

operation type. It will accommodate bars up to ⅞in. in diameter, and has a stock feed of 2in. It is primarily intended for work where comparatively small batches of articles are concerned and, consequently, the arrangements for setting up the tools are simplified as far as is possible. The spindle can be run at three speeds—1800, 2400, and 3000 r.p.m.—and the cam shaft, driven by a five-step cone pulley and worm reduction gearing, gives times per cycle of operations of 4, 6, 8, 11, and 16 seconds. Taper roller, ball journal, and thrust bearings are used at all important points, and parts subject to wear or requiring great accuracy are hardened and ground.

THE BRITISH THOMSON-HOUSTON COMPANY, LTD.

Various types of electric motors, with control gear, an electro-hydraulic thrustor, an electrically driven suds pump and fabroil gears and pinions, are shown by the British Thomson-Houston Company, of Rugby. Among the exhibits in operation is a four-speed, change-pole geared motor, Fig. 58,

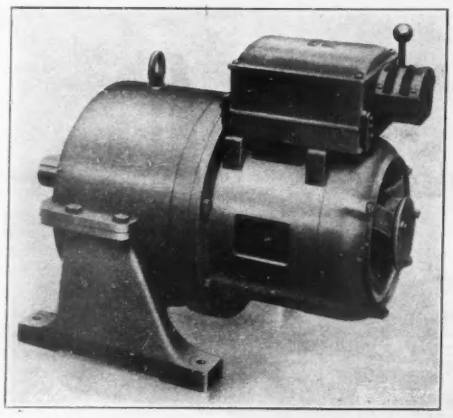


FIG. 58—VARIABLE SPEED GEARED MOTOR—B.T.H.

having a ratio of 10 to 1, and giving in all a choice of eight speeds, namely, 50, 100, 150, and 300 r.p.m. from the second motion shaft, and 500, 1000, 1500, and 3000 r.p.m. direct from the motor spindle, an arrangement which is also applicable to machine tools having built-in motor units. A four-speed change-pole selector switch mounted on top of the motor enables the various speeds to be obtained instantaneously while the load is maintained. The motor is protected by a contactor stator with silver contacts, which reduce the wear to a minimum when the starter is used at frequent intervals. The exhibit also demonstrates the action of the new B.T.H. relay, which enables the machine to be stopped instantaneously. The motor is started by the contactor in the usual way, and when quick stopping is desired a "plugging" contactor reverses the phases of the motor, which is therefore rapidly brought to rest. Reverse rotation is prevented by the "plugging" contactor being de-energised when the speed falls to a predetermined value. The scheme is particularly advantageous when a tool is liable to be damaged, or when, owing to some mishap, it is necessary to stop a machine to avoid injury to the operator.

Another equipment shown in operation which has

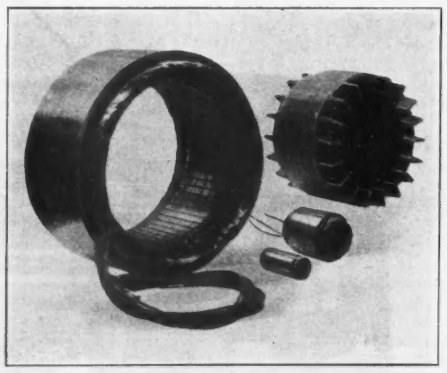


FIG. 59—STATOR AND ROTOR UNITS—B.T.H.

proved very successful in the woodworking industry, and is now being applied to metalworking tools, is a direct-motor-driven, high-speed spindle, applicable to grinding, fine drilling, and other work demanding a reliable beltless extra high-speed drive. The motor exhibited is capable of giving speeds of 17,000 and 11,000 r.p.m., but equipments can be supplied for speeds of 24,000 r.p.m. or more. These speeds naturally demand a higher frequency than the standard value, and the current is obtained from a single-unit frequency changer designed for 300 or 200 cycles per second.

For tapping purposes or any special duty cycle work demanding rapid reversal, a 5 horse-power motor is shown in operation capable of reversing at the rate of 60 or 100 times per minute. The machine is controlled by means of a reversing contactor capable of 100 reversals per minute, and with contacts capable of withstanding one million operations or more without replacement, irrespective of the duty.

The electro-hydraulic thrustor exhibited is no

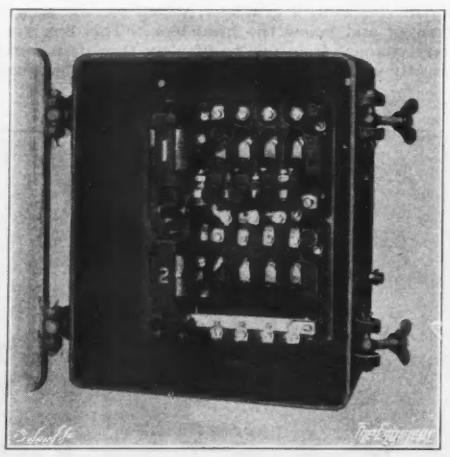


FIG. 60—DIRECT-ON-LINE REVERSING CONTACTOR STARTER—B.T.H.

longer new, and scarcely calls for description. Briefly, it is a device designed to exert a smooth straight-line constant pressure thrust on any mechanism it is desired to operate. The device shown in operation clearly demonstrates that it is useful when it is necessary to apply a pressure or to actuate a lever mechanism, or replace muscular effort through the medium of electric control on foot or hand-operated machines. Clutches and brakes are operated by the thrustor in a way which prevents strain and excessive wear.

Three fractional horse-power motors are shown. One is a flame-proof machine for use in places where there are inflammable gases and vapours. The other two motors are ball-bearing machines, one suitable for foot mounting and the other spigot mounting at any angle. The machines are representative of the wide range of fractional horse-power motors made by the B.T.H. Company for practically all purposes.

Squirrel-cage "built-in" type stator and rotor units (Fig. 59) as now extensively used on machine tools, both for main and auxiliary drives, constitute other exhibits. The units shown in Fig. 59 represent the extreme sizes, the wound stators being enclosed in drawn steel shells suitable for building into machine tool makers' frames. The centrifugally cast squirrel-cage rotors, in which the bars, end rings, and fins are cast in one piece by a patented process, are suitable for mounting directly on the machine tool shaft, which, like the bearings, end shields, and frames, are supplied by the tool makers. The illustration, Fig. 61, shows a vertical plano-miller made by Kendall and Gent and equipped with B.T.H. squirrel-cage induction motors for the main drive, table feed, and saddle feed.

Any type of built-in control gear is supplied by the B.T.H. Company to meet machine tool requirements. An automatic star-delta starter is shown mounted in its own case, whilst all the contactors, overload relays, &c., are mounted on

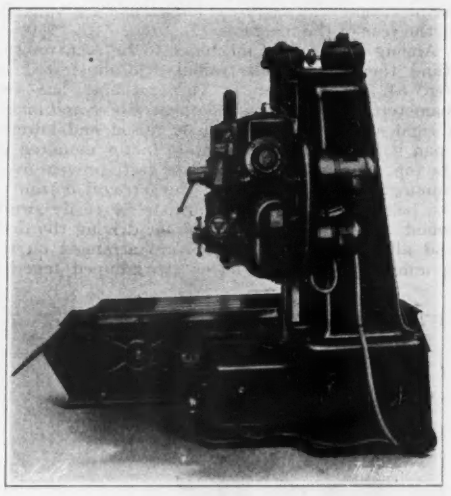


FIG. 61—MILLING MACHINE, WITH INDEPENDENT B.T.H. MOTOR DRIVES

a hinged panel to allow the units to be connected up and examined. The panels can also be supplied without the enclosing case for building into the machine tool. There is also a "direct on line" starter—Fig. 60—in a cast iron case, suitable for use in places where waterproof and dustproof equipment is essential, and a slow-break limit switch for machine tool work.

IMPERIAL CHEMICAL INDUSTRIES, LTD.

On the stand of Imperial Chemical Industries, Ltd., of Thames House, Millbank, London, there are four degreasing plants using trichlor-ethylene with which practical demonstrations are being given. The firm is asking all those having problems of their own to bring with them samples which will be treated on the stand. Three of the degreasing plants are gas-heated, and the remaining one electrically heated. A case-hardening furnace with a pot size of 10½in. by 15in. is shown in operation. It is capable of turning out 100 lb. of work per hour heat treated or carburised to a depth of 0·005in. The Cassel method of case hardening exemplified by this type of furnace employs, not a solid compound for introducing the carbon, but an agent in a molten state. The bath is made up of sodium cyanide and sodium carbonate, and the melt is maintained at a temperature of 700 deg. to 950 deg. Cent. It is said that with a bath of 50 per cent. cyanide strength at 950 deg. Cent. a case depth of sixty thousandths of an inch can be conferred on any mild steel parts after six hours' treatment.

An exhibit that is certain to attract attention is the new shrinking bath, in which "Drikold" is used. The bath consists of an outer shell surrounding the tank proper and insulated with a non-conducting material against heat leakage into the cooling medium, so that economy in the use of refrigerant is ensured. The bath is filled with a special fluid which does not freeze at the temperature of "Drikold" (—110 deg. Fah.). Removable partitions separate the portion of the bath into which the work is dipped from the parts in which the "Drikold" is placed. Slots are provided at the liquid level and a gap at the bottom of the partitions to facilitate circulation of the liquid and rapid heat transfer. Queries have been raised by a number of engineers, so the firm states, as to the possibility of metals becoming embrittled by cooling to such low temperatures. But the results of extensive research work have shown that, with the exception of metallic tin, no alteration was found to be produced in either the crystalline structure or the properties of a large range of ferrous and non-ferrous metals and alloys. The apparatus is suitable for the fitting of cylinder liners to internal combustion or other engines, the fitting of bushes in machine tool manufacture, the assembly of ball races on spindles and in houses, and for various other purposes.

A Seven-Day Journal

The Institution of Mining and Metallurgy.

Our readers are aware that the project for a central home in London for the constituents of the Empire Council of Mining and Metallurgical Institutions and the group representing chemistry and the chemical industries, has been in abeyance for some time. A site for the building (in Westminster) was secured on option a few years ago, but had to be abandoned owing to the general economic depression which supervened. The project is still in abeyance, and since it seems probable that the general industrial conditions may not permit of its revival in the near future, the Council of the Institution of Mining and Metallurgy has decided to take advantage of an opportunity of acquiring the leasehold of a self-contained suite of offices on the upper ground floor of Salisbury House, Finsbury-circus, with a separate entrance from the street in Circus-place, and arrangements are being made for removal from Cleveland House to the new premises in the second week of December. This decision has been approved by the Council of the Institution of Mining Engineers, and the close association of the two Institutions will therefore continue unimpaired, to their mutual advantage. The removal will be effected with the least possible interruption in the work of the Institution, but members are requested to note that it will be necessary to close the library service entirely from December 1st to December 15th, both days inclusive, and that all correspondence for the Institution should be addressed after December 10th next to the new address.

A West London Transport Outlet.

The Western Avenue, which has a length of 12 miles and is one of Greater London's most important arterial roads, is at last to be completed. Mr. Hore-Belisha, the Minister of Transport, has written to the Buckinghamshire and Middlesex County Councils, offering to consider an application from them for a grant for the construction of the last and most difficult section of the Avenue from Long-lane, Hillingdon, to Denham, in Buckinghamshire. That section of the Western Avenue which runs from Wood-lane, Shepherd's Bush, to Greenford-lane has been open for traffic as far westwards as Greenford for several years, and the further section from Greenford-lane to Long-lane, Hillingdon, which is now being built by the Middlesex County Council, under a grant from the Road Fund, will be ready for traffic probably before the New Year. The final section now under consideration is nearly 2½ miles in length, 1½ in Middlesex and the remainder in Buckinghamshire, and it passes through West Middlesex factory and housing sites as far as Fray's River. From that point westward to the Oxford Road a viaduct has to be built to carry the road over Fray's River, the Uxbridge branch of the Great Western Railway, the Grand Junction Canal, and the river Colne. The new section is to have an effective width of 87ft. with twin carriageways, each 27ft. wide, separated by a central reserve 14ft. wide and flanked by 9ft. 6in. wide footways. The viaduct will be 64ft. wide and will have a 44ft. carriageway with 4ft. wide central islands at intervals, and a 10ft. footway on each side of the carriageway. The estimated cost is £351,695. The experimental cycle tracks which are being laid on this road from Hanger-lane to Greenford-road, a distance of nearly 2½ miles, are nearing completion.

Beilby Memorial Awards.

The administrators of the Beilby Memorial Fund, consisting of the officers of the Institute of Chemistry, the Society of Chemical Industry, and the Institute of Metals, have announced the award of one hundred guineas each to Dr. William Hume-Rothery, M.A. (Oxon), Royal Society Warren Research Fellow, 1932, and to Dr. Ernest Albert Rudge, F.I.C. Dr. Hume-Rothery, who is thirty-five years of age, was educated at Cheltenham College and the Royal Military Academy, Woolwich. He entered Magdalen College, Oxford, and was elected to a Senior Demyship in 1925. He took First-class Honours in Chemistry at Oxford, and then worked at metallography for three years at the Royal School of Mines under the direction of Sir Harold Carpenter, F.R.S., after which he returned to Oxford for independent research work at the Old Chemistry Department, the University Museum, where accommodation was found for him by Professor F. Soddy, F.R.S. His published work includes a book on the Electrical Properties and Theories of Metals and Alloys, papers on Valency Relations in Alloy Structures and Determinations of Equilibrium Diagrams of Metallic Systems. He has introduced new conceptions and generalisations into the study of alloys, and has provided much new information as to the general laws and relations which determine the nature and properties of alloys. Dr. Ernest Albert Rudge is forty years of age, was educated at the Battersea Polytechnic, and from 1913 to 1915 at University College, London. After graduating B.Sc. (London) with First-class Honours in Chemistry in 1915, he was engaged as an analytical chemist first at Messrs. Johnson and Sons at their smelting works then as an analytical and research chemist in the Osram Robertson Lamp Works, and after demobilisation with the Morgan Crucible Company until July, 1919, when he was appointed a Lecturer in Chemistry at Cardiff Technical College. Since 1930 he has made a special study of the uses and behaviour of timbers in South Wales industries, and of the causes and circumstances of decay in industrial timbers. This year he has been awarded the degree of Ph.D for a thesis entitled "The Decomposition of Timber under Industrial Conditions."

Developing the Use of Steel.

The British Steelwork Association, which held its annual general meeting followed by a luncheon at the Hotel Victoria on November 9th, is the organisation which is entrusted with the task of developing the use of British steel. Practically all the constructional steel makers of the country are members of it, and, judging by the speeches, have every reason to be satisfied with the way its work is carried out. The President for the forthcoming year will be Mr. H. B. Jacks, of the British (Guest, Keen, Baldwins) Iron and Steel Company, Ltd. The Earl of Dudley, speaking at the luncheon, reminded his listeners that the good old days when steel sold itself and the manufacturers' problem was to produce enough to satisfy the clamour of his clients, were definitely past. The development of new continents with their railways, their docks, their harbours, and their bridges had receded into the past. He argued that the diversity of building regulations and the static concepts of site development had caused the existing pattern of street lay-out to be perpetuated with increasing traffic congestion. The time had arrived when stimulus should be given to the rebuilding of central London and other cities on lines which modern constructional technique had made possible, and the traffic problem thus tackled at its source. Mr. E. A. Wilson, the retiring President, who said he had seen the use of steel in building and constructional work develop from cast iron and wrought iron, referred to new high-tensile steels with 40 per cent. greater load-carrying capacity, and to that "infant prodigy" welding, which would give them an entirely new horizon.

Radio Interference.

A statement concerning the work of the Institution of Electrical Engineers Committee on Radio Interference, issued on Thursday, November 8th, draws attention to the fact that wireless listeners and those who advise them have not yet done all that is possible on receiving sets to mitigate some of the effects of interference. But even with the most favourable conditions the listener can provide, a large amount of interference can only be effectively corrected by suppressing it at the source by fitting condensers or condensers with choke coils to apparatus giving rise to trouble, and by improving the design of new apparatus. Early in its deliberations it appeared to the Committee that manufacturers should be made familiar with the methods of applying the necessary correction and should be given advice on how to appraise the interference. The Committee therefore took the initiative in the preparation of a specification covering this side of the subject, with a view to assisting manufacturers who desire to produce appliances incapable of giving trouble. While it may be difficult to apply correction to much of the existing apparatus, there seemed to be every reason to make the way as plain as possible to those who are anxious to make new apparatus inoffensive. In the preparation of the specification the Committee had the co-operation of the British Standards Institution, and it is expected that it will be possible to issue the specification early next year as a British Standard. The Committee is reluctant to be dogmatic on the subject of compulsory *versus* voluntary suppression of radio interference. There is much goodwill among all concerned, and it is believed that a threat to impose compulsory regulations at the moment might have the effect of retarding progress. Manufacturers have been willing to design non-interfering apparatus, but on account of the increased price there may be a reluctance to market such apparatus until the requirement is made to apply to all, including importers. This, however, is not at the moment a practical issue, for the Committee considers that more experience and investigations are necessary before there can be any feeling of certainty that the proposed standards and methods of appraisement of interference can be effectively included in any form of official regulations.

The Melchett Medal.

On Monday of this week November 12th at the eighth annual dinner of the Institute of Fuel held at the Connaught Rooms, London in the presence of over 750 members and guests, His Royal Highness the Duke of Kent presented the Institute's Melchett Medal to Dr. Friedrich Bergius in recognition of the eminent work which he has done in connection with the production of oil from coal by the hydrogenation process. Friedrich Karl Rudolf Bergius was born in Silesia in 1884. His father owned a chemical factory at Goldschmieden, and was a pioneer of the aluminium industry. Following a short period of practical work in the Ruhr coal-mining area he studied chemistry at the University of Breslau and later at Leipzig. Thereafter he took his doctor's degree, was appointed Lecturer at Leipzig and subsequently worked at the Nernst Institute, Berlin and at the Haber Institute, Karlsruhe. In 1909 he joined the Institute of Physical Chemistry at Hanover and began investigations on the dissociation of chemical compounds at high pressures up to 300 atmospheres. In 1910 he fitted up a private laboratory to extend the range of his high-pressure studies. The laboratory was gradually extended, workshops were added, co-workers were engaged and facilities for large-scale experiments provided. In 1912 and 1913 he discovered the effect on coals and oils of hydrogen under high pressure. In 1914 he accepted a proposal to transfer his investigations to the Theo. Goldschmidt works at Essen. During the war years the technical development of his hydrogenation processes was intensively studied and a plant for the purpose was begun at Rheinau, near Mannheim. At the same time other high-pressure work was under development at Essen namely the manufacture of glycol from ethylene choride and the conversion of wood into sugar. After the war he sought collaboration in the commercial development of his hydrogenation processes, and in 1927 having proved the possibility of liquefying coal on a large scale he handed over the industrial development of the work to the I. G. Farbenindustrie A.G. and to Imperial Chemical Industries. The second-named company is now expending a sum of £3,000,000 on the erection of a hydrogenation plant at Billingham. Dr. Bergius thereafter turned his attention to his process for converting wood into sugar and succeeded to such an extent that in 1932–33 an industrial wood saccharification plant was established at the old Rheinau works. An enlargement of this works is now in hand and by the early summer of next year the plant will be capable of producing from wood 6000 tons of crude sugar per year.

Level Crossings.

Three level crossings in Durham and Nottinghamshire, which have been a source of delay and potential danger to traffic, are to be eliminated at a cost of £145,000, the greater part of which will be borne by the Road Fund. Mr. Hore-Belisha, Minister of Transport, has approved a scheme submitted by the Durham County Council for the building, as soon as possible, of a bridge over the London and North-Eastern Railway on the Billingham-Haverton Hill Road at a cost, including approach roads, of £85,300. This bridge is urgently needed to relieve the serious traffic congestion caused by the long and narrow level crossing opposite the works of Imperial Chemical Industries, Ltd., at Haverton Hill. It will have a total length with approach roads of half a mile and will accommodate a 30ft. carriageway and two 10ft. footpaths. A similar grant has also been made towards the cost of a scheme submitted by the Nottinghamshire County Council for the construction at Babworth, Retford, of a 50ft. wide bridge and viaduct. This reinforced concrete bridge will eliminate a level crossing on the Retford-Worksop Road, a short distance from the junction with the Great North Road. In addition, the bridge over the Chesterfield Canal, almost immediately east of the level crossing, is to be widened and re-aligned to accommodate a 35ft. carriageway and two footways. Earlier in the year approval was given to a scheme for the construction of a similar bridge and viaduct to replace the level crossing on the Newark-Lincoln Road at Newark and work on this scheme is to begin almost immediately.

Liners Sold for Breaking Up.

The announcement is made that the two modern 19,890 gross ton, 16½-knot, Transatlantic cargo and passenger liners, "Minnewaska" and "Minnetonka," belonging to the Atlantic Transport Company, Ltd., have been sold for breaking up to Messrs. Douglas and Ramsay, of Glasgow. The ships are equipped with modern oil-fired boilers and turbine machinery, and were built and engined by Harland and Wolff, Ltd., in 1923 and 1924, at a cost of between £1,250,000 and £1,100,000 each. After ten or eleven years' service, they have now been disposed of at a price, we are given to understand, of well below £50,000 each. In normal trading years such liners would undoubtedly have had many years of useful service still ahead of them. When they were built they carried good cargoes, and until 1931 accommodation was provided for 400 first-class passengers. In 1932 and 1933 tourist passengers were carried, and since October, 1933, they have been laid up at Antwerp. Both ships were well supported by passengers, but under the prevailing economic conditions of recent years it was seldom, if ever, possible to use all the cargo space. The decision to sell the liners will mean the retirement of Captain Thomas F. Gates, a popular officer, who in turn commanded both liners. The Compagnie Générale Transatlantique has recently sold the 23,769-ton liner "France," built at St. Nazaire in 1912, for breaking up by a Dunkerque firm.

Gaseous Specific Heats and Internal Combustion Engine Efficiencies.

By Professor W. T. DAVID.

ALMOST serviceable contribution towards the development of internal combustion engine theory, and, indeed, combustion theory generally, would be the discovery of accurate information relating to the specific heats at high temperatures of the products of combustion and diluent gases associated with them. At present there are in common use many systems of specific heats which differ widely from one another, but experiments recently made in this laboratory[1] indicate that the specific heat values calculated from selected optical data upon the basis of the Planck-Einstein quantum expression are substantially accurate up to temperatures of at least 2500 deg. Cent., with the possible exception of those for water vapour, which, however, may be accepted without serious error up to a temperature of about 2250 deg. Cent.

It is proposed to give in this paper a brief review of the experiments which prove the accuracy of these specific heats and afterwards to review in the light of them the ideal temperatures which should be attained in flame gases and also the efficiencies of internal combustion engines.

The Theoretical Specific Heats.

The specific heats calculated upon the Planck-Einstein basis are given in Table I. Those for H_2, CO, N_2, CO_2, and H_2O were calculated by Nernst and Wohl,[2] and those for O_2 are the more recent calculations of Johnstone and Walker.[3]

Table I.—*Mean Theoretical Specific Heats at Constant Volume Over the Temperature Range 0 Deg. to t Deg. Cent. in Foot-pounds per Standard Cubic Foot.*

t° C.	0.	100.	200.	300.	527.	927.	1127.	1327.	1727.	2127.	2527.
H_2	18·8	19·15	19·2	19·3	19·4	19·75	20·05	20·35	20·9	21·55	22·1
N_2	19·4	19·4	19·45	19·6	20·15	21·2	21·6	22·1	22·8	23·4	23·8
CO	19·4	19·45	19·5	19·76	20·35	21·55	22·0	22·4	23·0	23·8	24·2
O_2	19·55	19·8	20·2	20·6	21·6	22·9	23·4	23·9	24·6	25·0	25·4
CO_2	25·85	28·0	29·95	31·5	34·4	38·1	39·3	40·4	42·1	43·3	44·5
H_2O	23·4	23·6	23·95	24·35	25·4	27·6	28·7	29·7	31·6	33·2	34·35
In Cals. per Gm. Mol.											
t° C.	0.	100.	200.	300.	527.	927.	1127.	1327.	1727.	2137.	2527.
H_2	4·82	4·91	4·93	4·94	4·97	5·06	5·14	5·21	5·36	5·52	5·66
N_2	4·97	4·97	4·99	5·03	5·16	5·43	5·55	5·67	5·85	6·0	6·1
CO	4·97	4·98	5·00	5·06	5·22	5·52	5·65	5·76	5·9	6·1	6·2
O_2	5·01	5·08	5·17	5·29	5·54	5·86	6·01	6·12	6·29	6·4	6·5
CO_2	6·63	7·18	7·67	8·08	8·84	9·77	10·08	10·37	10·8	11·1	11·4
H_2O	6·0	6·05	6·14	6·24	6·53	7·09	7·35	7·61	8·1	8·5	8·8

For convenience we will refer to these specific heats as the "theoretical specific heats."

It will be of interest to compare this system of specific heats with the other systems in common use, for example, the Partington and Shilling system[4] (which extends up to 2000 deg. Cent. only, except in the case of H_2O, where the temperature range

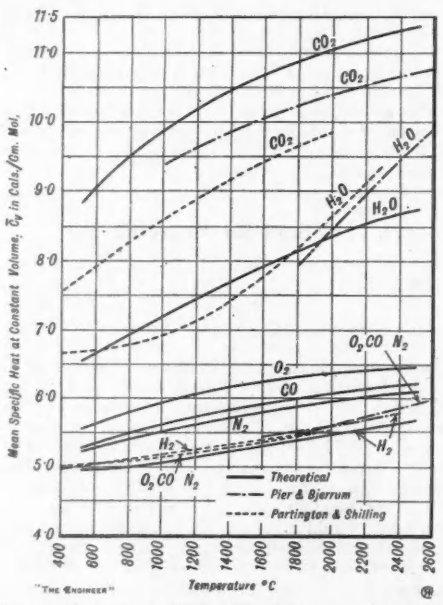


FIG. 1—SPECIFIC HEATS ACCORDING TO VARIOUS AUTHORITIES

extends to 2300 deg. Cent.), and the Pier and Bjerrum system.[5] This is done in Fig. 1. It will be seen that the theoretical specific heats of the triatomic gases CO_2 and H_2O are considerably different from both the Partington and Shilling and the Pier and Bjerrum values. But the most noticeable feature of the theoretical system is that the values for the diatomic gases H_2, O_2, N_2, and CO are widely different, whereas in the other systems the values are the same for these gases, except in the case of H_2, the values for which are slightly different.

Experimental Verification of the Theoretical Specific Heats.

At low temperatures, up to about 600 deg. Cent., the work of Henry,[6] Eucken and Mucke,[7] and Knoblauch, Raisch and Haussen[8] has given remarkable confirmation of the theoretical system. This will be seen from an examination of Fig. 2, in which the theoretical values for the various gases are shown together with the experimental values determined by the above mentioned observers.

In passing it will be of interest to indicate why the Partington and Shilling values differ from the correct values. These observers determined their specific heats by the velocity of sound method. But it has been shown by Kneser[9] that values so found depend very much upon the frequency of the sound waves employed. This will be clear from an inspection of Fig. 3. It will be seen that the higher the frequency the lower the specific heat value determined and the lower the frequency the closer the approximation of the determined value to the theoretical value. The explanation is that with high-frequency sound waves there is no time for the vibratory energy of the molecules constituting the gas through which the waves pass to reach its equilibrium value, and consequently the specific heat values, which depend upon the vibratory as well as the translational and rotational energy of the molecules, are too low.

At high temperatures practically the only method of determining the specific heat of gases is that known as the explosion method. In this method, which is

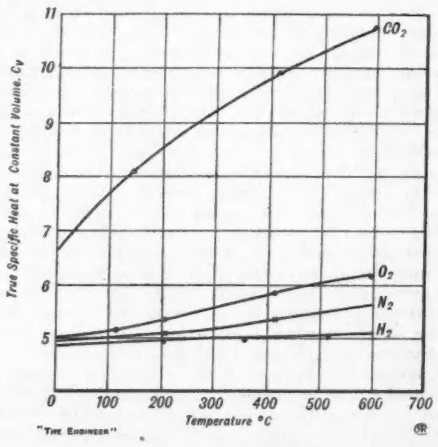


FIG. 2—THEORETICAL AND OBSERVED SPECIFIC HEATS

well known, inflammable gases contained in a closed vessel are exploded and the maximum pressures developed are measured. From the maximum pressures the maximum mean temperatures are calculated, and from these temperatures and the known heat of combustion of the inflammable gases the mean specific heats of the products of combustion are inferred after making an allowance, generally guessed, of the heat loss during explosion.

Apart from the heat loss allowances, which actual measurements[10] have shown to be very different from those often assumed, it is not generally recognised that allowance has also to be made for the fact that combustion, defined in the sense of the overall process of conversion of chemical energy into internal or thermal energy, is not complete at the moment of maximum pressure. The method as usually employed must therefore lead to incorrect results unless means can be found for estimating the amount of incomplete combustion obtaining at maximum pressure. Experiments have shown that the amount of incomplete combustion at maximum pressure decreases as the size of the explosion vessel increases[11] and also as the initial density of the gaseous mixture to be exploded increases. It seems possible, though it is by no means certain, that with a very large explosion vessel of the order of perhaps 50in. diameter and an initial density of perhaps 20 atmospheres the amount of incomplete combustion would be reduced to negligible proportions, and under such circumstances the explosion method might be a reliable one. Large-scale experiments of this kind, however, would be

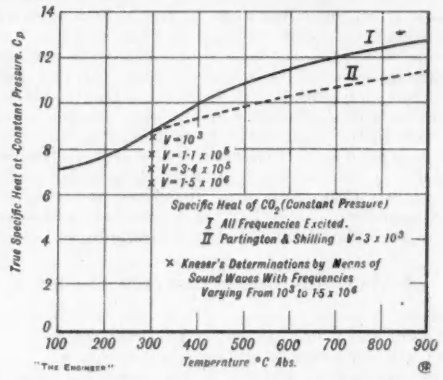

True Specific Heat at Constant Pressure, C_p
Temperature °C Abs.
"The Engineer"
I
II
V = 10³
V = 1·1 x 10⁵
V = 3·4 x 10⁵
V = 1·5 x 10⁶
Specific Heat of CO_2 (Constant Pressure)
I All Frequencies Excited.
II Partington & Shilling V = 3 x 10³
Kneser's Determinations by Means of Sound Waves With Frequencies Varying From 10³ to 1·5 x 10⁶

FIG. 3—EFFECT OF FREQUENCY OF SOUND IN DETERMINING SPECIFIC HEATS

very costly, and, accepting the fact of incomplete combustion, we have, with the largest and strongest spherical vessel available to us, used the explosion method for checking the various systems of specific heats.

The results of some of our experiments, which were made by Dr. Smeeton Leah and the writer, are summarised in Table II. These experiments were made with the object of checking the mean specific heats in the neighbourhood of 2000 deg. Cent.[12] for the gases H_2, O_2, N_2, CO, H_2O, and CO_2. The inflammable gaseous mixtures shown in column 1 of the table were exploded by means of a centrally placed spark in a spherical vessel 18in. in diameter at an initial density of 3 atmospheres. Arrangements were made for the accurate recording of both the maximum pressures and the heat losses up to the moment of maximum pressure. The ratios of the maximum pressure to the initial pressure, corrected to an initial temperature of 20 deg. Cent., are shown in column 3, and the heat losses up to maximum pressure (h_m) expressed as a percentage of the heat of combustion of the inflammable mixtures in column 4.

The temperature rises after explosion (deduced from the measured maximum pressures) are shown in column 5, and in column 6 are shown the calorific values (Q) per gramme molecule of the mixtures before explosion. In the remaining eight columns are shown the results of calculations upon the basis of the various systems of specific heats of :—

(i) The internal energy (E) of the products of combustion at maximum explosion temperature per gramme molecule of the mixtures before explosion ; and

(ii) The unaccounted energy or incomplete combustion (U.E. %) expressed as a percentage of the heat of combustion of the mixtures before explosion, U.E. $\% = 100 \left(\frac{Q-E}{Q}\right) - h_m$.

It will be seen that according to the Partington and Shilling, the Pier and Bjerrum, and the Goodenough and Felbeck systems of specific heats the variations in the unaccounted energy or incomplete combustion in these explosions is enormous. According to the Partington and Shilling system, for example, it varies from 0·3 per cent. to 13·5 per cent., and the variation is not much less according to the Pier and Bjerrum and the Goodenough and Felbeck systems. On the other hand, according to the theoretical system the variation is very small indeed, and this must be regarded as convincing confirmation of the substantial accuracy of the relative values of the mean theoretical values over the range 0 deg. Cent. to 2000 deg. Cent. in the case of the gases H_2, O_2, CO, N_2, H_2O, and CO_2—all of which were present in varying proportions in these and other experiments

[1] Engineering Department, University of Leeds.
[2] *Zeit. f. Tech. Phys.*, 10 (1929), p. 613.
[3] *J.*, Amer. Chem. Soc., 55, i (1933), p. 172.
[4] "The Specific Heat of Gases," Benn, 1924.
[5] *Zeit. Electrochem.*, 17 (1911), p. 731 ; 18 (1912), p. 101.
[6] "Proc.," Roy. Soc. A., Vol. CXXXIII (1931), p. 492.
[7] *Zeit. f. Phys. Chem. B.*, 18 (1932), p. 167.
[8] See *Zeit. Phys. Chem.*, B5 (1929), p. 257.
[9] *Ann. Physik*, XI (1931), p. 777.
[10] *Phil. Mag.*, Vol. xiv (1932), p. 764.
[11] *Phil. Mag.*, Vol. xiv (1932), p. 764 ; and Vol. xviii (1934) p. 312.
[12] That is, the mean specific heats over the range 0 deg. to 2000 deg. Cent.

giving similar results. It should be added that while experience had suggested that the amount of incomplete combustion should be more or less constant within the CO group and the H_2 group, it was an unexpected result to find that the amount was practically the same in the two groups. Probably this would not be the case in vessels of other sizes and with mixtures at other densities.

It has been hoped to check the absolute accuracy of the theoretical specific heats by making similar explosion experiments with the monatomic gas argon as the main diluent, maintaining, as in the previous experiments, an excess of one of the reacting gases in the mixtures. The incomplete combustion estimates inferred from these experiments, using the theoretical specific heats for the triatomic and diatomic gases present in the mixtures after explosion, were, however, appreciably higher, being of the order of 5 or 6 per cent., as compared with about 2·5 per cent. in the experiments summarised in Table II.

At first sight, therefore, it would appear that although the relative values of the mean theoretical specific heats at 2000 deg. Cent. of H_2, O_2, N_2, CO, H_2O, and CO_2 are correct, their absolute values are a little too high—about 4 or 5 per cent. too high. But on many grounds this is most unlikely, and it seems probable that for some reason or other the monatomic gas argon has a tendency to inhibit the overall process of combustion, or, to put the matter in another way, the diluent gas argon would not appear to deactivate the abnormal CO_2 and H_2O molecules formed during combustion as effectively as do diatomic and triatomic diluents. There seems to be considerable evidence of a general kind in favour of this view.[13] Experiments made in Professor Bone's laboratory also suggest that for the purpose of specific heat estimates the argon experiments may be disregarded. These experiments showed that when the monatomic gas helium was substituted for argon in explosive mixtures quite different results were obtained.[14]

Experiments have also been made with stronger mixtures than those shown in Table II,[15] and they indicate that the mean theoretical specific heats are substantially correct for CO, N_2, and CO_2, and probably for H_2 and O_2, up to at least 2500 deg. Cent. The theoretical values for H_2O above about 2000 deg. Cent. would appear to require further investigation, but the inaccuracies resulting from their use at temperatures up to about 2250 deg. Cent. will not be serious.

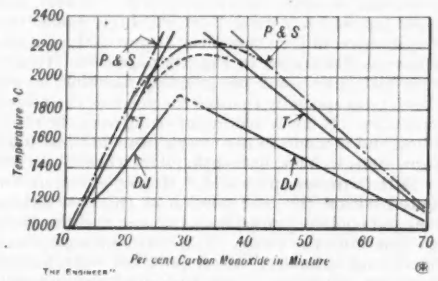


FIG. 4—FLAME TEMPERATURES

Flame Temperatures.

Ideal flame temperatures, or temperatures which should ideally be obtained in constant pressure combustion, calculated upon the basis of the theoretical specific heats, are shown for CO-air mixtures and for methane-air mixtures in Figs. 4 and 5 (curves T). In the same figures are shown the temperatures which should ideally be obtained assuming the frequently employed Partington and Shilling system of specific heats (curves P and S). An examination of these curves shows that the theoretical system of specific heats yields temperatures very much lower (some 50 deg. to 100 deg. Cent. lower) than those yielded by the Partington and Shilling system. Most other systems yield temperatures which are intermediate between the theoretical and the Partington and Shilling temperatures.

In making these calculations it has been assumed that combustion is complete and no allowance has been made for heat loss by radiation. Measurements of radiation from flames show that some 10 per cent. of the heat of combustion is lost in this way, but it is now clear that nothing like this amount has been lost by the inflamed gases by the time they have reached the point at which temperature measurements are made in open flames. About 2 per cent. would be a generous estimate for the radiation loss up to this point.[16]

Incomplete combustion (defining "combustion" in the sense of the overall process of conversion of chemical energy into internal or thermal energy) is very large in ordinary flames in which combustion takes place at atmospheric pressure. This will at once be clear when actual measurements of flame temperatures are compared with the ideals. These are shown by the curves D J, which summarise experiments made by Dr. J. Jordan and the writer.[17] It will be seen that the actual flame temperatures are many hundreds of degrees Cent. below the ideal temperatures.

The incomplete combustion probably does not result from incomplete combination, at any rate as ordinarily understood, and as has been shown in a previous paper,[18] it seems best to refer to it as latent energy in the flame gases. In the same paper it was shown that the actual flame temperatures increase considerably, and therefore the latent energy decreases, as the pressure at which burning takes place increases.

Internal Combustion Engine Efficiencies.

The theoretical specific heats yield ideal internal combustion engine efficiencies which are some 4 or 5 per cent. lower than those yielded by the Pier and Bjerrum system, which has been popularised in this country through the pioneer work of Tizard and Pye. For example, in an engine of compression ratio 5 : 1 working on a benzene mixture 75 per cent. of the correct, the ideal efficiency calculated upon the basis of the theoretical system of specific heats is only 36·5 per cent., as compared with 38·3 per cent. when calculated upon the basis of the Pier and Bjerrum system.

No difficulty arises as between theory and experiment from the new standard set up by the theoretical specific heats in the case of slow-speed engines. This will be clear from an inspection of the figures in Table III, which relate to Hopkinson's classical experiments with a 40 H.P. gas engine running at 180 r.p.m. with a compression ratio of 6·37. It will be seen that sufficient margin exists between the theoretical specific heats standard and Hopkinson's actual results to allow for all the losses in the actual engine.

Table III.

Mixture.	Thermal efficiencies. per cent. Ideal.	Actual.	Difference.
"Weak" (8·8 per cent. of coal gas in cylinder contents)	43·1	37·0	6·1
"Strong" (11·4 per cent. of coal gas in cylinder contents)	41·1	33·0	8·1

In the case of high-speed non-injection engines—that is, engines running at a speed of 1000 r.p.m. and over—there has always been a doubt as to whether the measured indicated thermal efficiencies do not approach rather too closely to the ideal standard based upon the Pier and Bjerrum specific heats, having regard to the more or less known losses which occur in these engines.[19] But there seems to be little doubt that they are too close to the new standard set up by the theoretical specific heats.

In illustration of this the efficiency figures shown in Table IV may be examined. It will be seen that the difference between the ideal and the measured efficiencies scarcely covers the loss in efficiency due to heat loss during the explosion-expansion stroke, without taking into account losses due to incomplete combustion, early release towards the end of expansion, &c.

The figures given in Table IV relate to weak mixtures of gaseous fuels, and it seems almost certain from preliminary investigations that the approach of the measured efficiency to the ideal is even closer when engines are run on stronger and over-rich mixtures. It seems certain also that the approach to the ideal is too close in the case of engines running on liquid fuels, but exact figures illustrative of this must await reliable information relating to the specific heat of H_2O in the neighbourhood of 3000 deg. Cent.

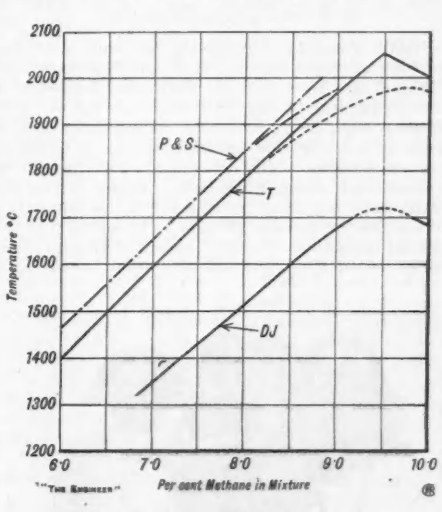


FIG. 5—FLAME TEMPERATURES

Table II.

Inflammable mixture percentages.	Diluent gases percentages.	$\left[\frac{P_m}{P_i}\right]$ 20°.	h_m, per cent.	$T_m - T_i$, °C.	Q.	System of specific heats used. Theoretical. E.	Theoretical. U.E.%.	Partington and Shilling. E.	Partington and Shilling. U.E. %.	Pier and Bjerrum. E.	Pier and Bjerrum. U.E. %.	Goodenough and Felbeck. E.	Goodenough and Felbeck. U.E. %.
16·03 CO+4·37 H_2+10·2 O_2	69·4 O_2	6·90	1·4	1960	13,300	12,800	2·4	11,320	13·5	11,530	11·9	11,740	10·4
19·82 CO+1 H_2+10·41 O_2	68·77 CO	7·31	0·8	2095	13,940	13,470	2·6	12,350	10·6	12,650	8·4	12,830	7·2
15·08 CO+5·02 H_2+10·05 O_2	50·68 N_2+19·17 CO	7·10	0·6	2020	13,040	12,560	2·4	11,730	9·4	11,960	7·7	12,200	5·8
22·94 CO+1 H_2+11·97 O_2	22·57 CO_2+41·52 CO	6·99	1·1	2030	16,030	15,480	2·3	14,000	11·6	14,520	8·4	14,670	7·4
24·94 CO+1 H_2+12·97 O_2	34·59 CO_2+26·5 CO	6·87	1·5	2020	17,370	16,700	2·4	15,000	12·2	15,690	8·2	15,810	7·5
20·84 H_2+10·42 O_2	67·8 H_2+0·94 H_2O	7·29	*	2095	11,930	11,630	2·5	11,900	0·3	11,930	0	11,740	1·6
21·58 H_2+10·79 O_2	57·29 N_2+9·59 H_2+0·75 H_2O	7·19	*	2070	12,340	12,070	2·2	11,780	4·5	11,770	4·6	11,900	3·6
29·10 H_2+14·55 O_2	40·45 CO_2+15·02 H_2+0·88 H_2O	6·93	*	2085	16,700	16,330	2·2	15,600	6·6	15,950	4·5	15,970	4·4

* Very small, certainly less than ¼ per cent.

Table V.

Engine	A.	B.	C.
Cylinder diameter, inches	3·25	4·5	8·0
R.p.m.	1750	1750	1250
Mean piston speed, feet per minute	1166	2333	2290
Compression ratio	4·84	4·84	4·84
Indicated thermal efficiency with petrol mixture 5 per cent. weak, per cent.	29·6	30·8	32·0

The efficiency measurements given in Table IV were all made on an engine with a cylinder of 4·5in.

Table IV.—*Efficiencies of High-speed Engines of Compression Ratio 5 : 1 when Running on Various Fuels, Mixture Strength, 70 Per Cent. of the Correct in Each Case.*

Fuel.	Engine speed, r.p.m.	Thermal efficiencies, per cent. Ideal.	Actual.	Difference.	Observer.
Methane	1000	38·0	35·0	3·0	A. F. Burstall
Coal gas	1000	37·0	34·0	3·0	A. F. Burstall
	1400	37·0	35·5	1·5	A. F. Burstall
Carbon monoxide	1000	33·5	30·2	3·3	A. F. Burstall. Heat loss large because of very early ignition
Hydrogen	1400	37·0	33·7	3·3	Ricardo. Corrected from C.R. of 5·45 : 1

In the case of high-speed non-injection engines—that is, engines running at a speed of 1000 r.p.m. and over—there has always been a doubt as to whether the measured indicated thermal efficiencies do not approach rather too closely to the ideal standard diameter, and it seems highly probable that still higher efficiencies would have been measured in larger engines running under similar conditions. Ricardo's experiments upon similar engines of different sizes seem to prove this.[20] His results are shown in Table V. It will be seen that there is a substantial improvement in efficiency as the engine cylinder is increased in size from 4·5in. to 8in. dia-

[13] See "Fluorescenz und Phosphorescenz," R. Pringsheim (Springer), 1928.

[14] "Gaseous Combustion at High Pressures," Bone, Newitt, and Townend (Longmans), 1929, p. 215.

[15] *Phil. Mag.*, Vol. xviii (1934), p. 316.

[16] *Phil. Mag.*, Vol. xvii (1934), p. 179.

[17] *Phil. Mag.*, Vol. xvii (1934), p. 176.

[18] "Temperature and Latent Energy in Flame Gases," THE ENGINEER, June 1st, 1934.

[19] See "Engines of High Output," H. R. Ricardo (Macdonald and Evans), 1926, p. 49.

[20] "The Internal-Combustion Engine," Vol. II (Blackie), 1923, p. 85.

meter, and this is in keeping with the well-known experiments upon the L, R, and X engines carried out by a committee of the Institution of Civil Engineers.

It seems clear, therefore, that were it possible to suppress all losses in the high-speed engines their efficiencies would be greater than the ideal efficiency standards set up by the theoretical specific heats.

This somewhat startling conclusion suggests at once that the theoretical specific heats are far too high (just as flame temperatures suggest that they are far too low), but this, it is believed, is not the case. They may be, and probably are, subject to small errors, but these are almost certainly in the wrong direction, and in any case they would not affect appreciably the efficiency calculations.

Tentatively it is suggested that the probable explanation is that in high-speed engines the explosion process is so rapid that there is no time for the molecules of the diluent gases to attain their equilibrium share of intra-molecular (vibratory) energy and thus behave as though they possessed lower specific heats than their true specific heats under corresponding conditions of temperature. The experiments of Kneser, summarised in Fig. 3 of this paper, lend interesting support to this suggestion.

If this suggested explanation is correct the indicated thermal efficiency should, other things being the same, increase with speed, though the effect is offset to some extent by the fact that incomplete combustion increases with speed.[21] The experiments of A. F. Burstall[22] indicate that there is a marked increase in efficiency as an engine is speeded up from 300 to 1000 r.p.m., but only a relatively small increase over the range 1000 to 2000 r.p.m.

In order to secure the highest efficiencies, in addition to high compression ratios, the aim should apparently be the building of the largest cylinders consistent with the highest speeds. An attempt to give a rational theory for this view will be made in a subsequent paper.

I should like to express my thanks to Dr. A. Smeeton Leah for valuable assistance, and to Mr. A. D. Wilson, B.Sc., for making the engine efficiency calculations.

The Machine Tool and Engineering Exhibition at Olympia.

No. II.

(*Continued from page 455, November 9th.*)

S. Russell and Sons, Ltd.

A NEW design of cold sawing machine, with the feed operated hydraulically, which is shown by S. Russell and Sons, Ltd., of Bath-lane, Leicester, is illustrated by Fig. 14, page 486. It is made in three sizes for saws 26in., 28in., and 30in. in diameter, and is driven by a motor of about 10 horse-power, mounted on the saw saddle. The drive is effected through an inverted tooth chain or Vee belts. Within the saddle casting there is a set of gearing that gives four ratios and enables the speed of the saw to be adapted to the material being cut. These gears are of the spur and double helical type, and are of special heat-treated steel. The high-speed shafts run in ball bearings, while the saw spindle and second shaft have gun-metal bearings. The whole of the driving gear runs in an oil bath, and a window is provided to show the height of the oil. Wipers are provided to prevent fine swarf being trapped under the slide. The hydraulic feed is operated by two pumps housed in the main bed, and driven by a separate motor of 2 H.P. One of the pumps has a variable stroke and is used for the feed proper, while the other, with a constant delivery, is used in connection with the feed cylinder counter pressure, vice-gripping, and the quick-return movement of the saddle. The arrangement of the feed is such that the saw cannot possibly be pulled into the work by the action of the cut, and there is a relief valve to prevent the saw being fed forward against too great a resistance. The vice has a vertical gripping action, which can be operated either hydraulically or by a hand wheel. The hydraulic cylinder is built into the body of the vice and acts through toggles, so that when the full grip is attained the cylinder is relieved of the strain. An attachment on the press block prevents short lengths of material from being thrown upwards by the saw blade when they are actually severed from the stock. On the side of the machine into which the stock is fed there is a power-driven roller, which can be raised by a foot pedal to take the weight of the bar, and feed it forward against a stop ready for the next cut. This lifting action can be operated hydraulically if desired. There is a device for clearing away the chips from the cutting edges of the saw and an adequate supply of cooling liquid is provided by a pump drawing from a sump in the base. The largest of these three machines is capable of severing a joist measuring 16in. by 8½in., or a round 10½in. in diameter, while the other two have slightly smaller capacities. Otherwise they are almost identical in particulars.

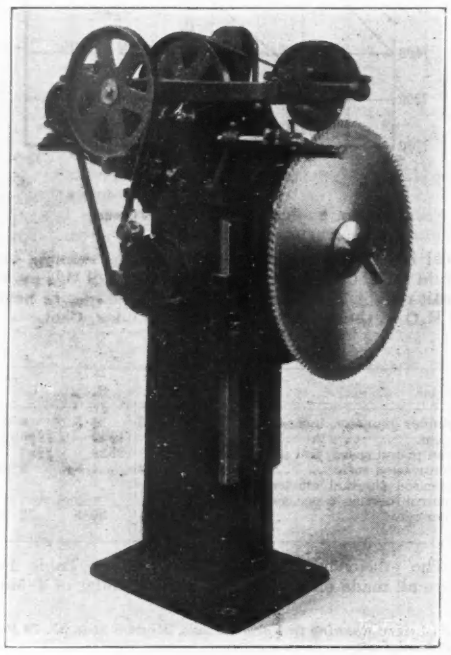


FIG. 11—SAW SHARPENER—RUSSELL

The saw sharpener illustrated by Fig. 11, which is also by Messrs. Russell, is actually shown on the stand of Chas. Churchill and Co., Ltd. It has been specially designed for sharpening the inserted segment type of cold saw, such as those used in the sawing machine just described, in which arduous service it is essential that the teeth should be both sharp and correctly formed. For this reason the machine is devised to grind the saw teeth to conform to a template, an arrangement which is a great convenience should one of the teeth break out and have to be replaced by one of new, full, section. Saws of from 15in. to 40in. in diameter, with teeth of from ¼in. to 2in. pitch, can be ground and the machine requires only 1 horse-power.

Hermann Pfauter.

The full range of specialised gear and spline hobbing and thread milling machines which is built by Hermann Pfauter, of Chemnitz, is well represented by a working group of about twelve machines exhibited on the stand of Dowding and Doll, Ltd., of Greycoat-street, Westminster, London, S.W.1, the firm which represents Pfauter interests in this country. The principal machines are automatic gear hobbers of small and medium sizes, which are shown in actual operation on varied forms of gear cutting chosen to illustrate the modern methods of production used in various branches of industry. Additional machines are the Pfauter hob-sharpening machine with fully automatic operation, and an automatic worm and thread-milling machine. From this group we have chosen for illustration and further description the large RS9 gear and spline hobber, specially designed for hobbing heavy splines, which is shown in Fig. 15 on p. 486 and Fig. 12. The relative motions of the cutter and work may be compared with those of a worm and worm wheel. The worm-like cutter or hob is inclined to the axis of the work, and its speed so correlated with the feed of the work that all the spline teeth are cut simultaneously. The outline and detail parts of the machine clearly illustrate the marked tendency in the firm's latest designs to give increased dimensions to all the main machine parts, so as to enable them to meet the requirements of higher working speeds and heavier cutting duties. Attention may be called to the characteristic rounded rectangular box forms of the machine base and upper parts, such as gear-boxes, hobbing head, and table, which gives, it is claimed, strength combined with great rigidity. The whole of the gearing is completely enclosed, a neat entry for the driving belt being left open. On this particular machine the work head spindle is designed to admit work up to 4in. in diameter, and a single-lever rapid clamping tailstock is provided, which, we understand, has proved especially advantageous when dealing with certain types of motor car components. The hobbing head has a fly-wheel and all the driving gears are of steel, and they mesh with forged bronze wheels, while the bevel drives are of the spiral gear type. In order to simplify as far as possible the reversing of the machine when cutting, for example, left-hand spirals, a patented arrangement of pick-off gears mounted on three studs is used, which enables the hob speed to be varied. Engraving Fig. 12 shows these gears and also illustrates the enclosed differential gearing and the centralised system of lubrication. All the shafts of the machine, including the table worm shaft, carry six-key splines, which are hobbed from the solid. The combined facilities provided for radial and for axial adjustment enable full use to be made of the high accuracy of the

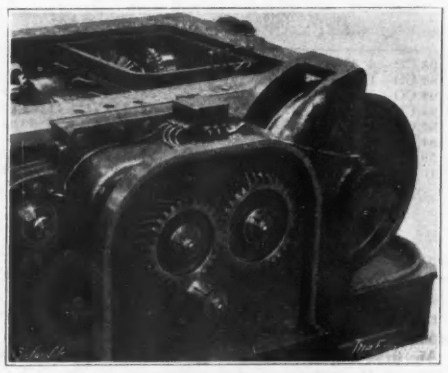


FIG. 12—PICK-OFF REVERSE GEARS—PFAUTER

Pfauter dividing worm and wheel. The dividing worm is mounted in such a way that it is supported on either side independently of its driving shaft. It is made of nitrided steel and is hardened and ground all over, and the index worm is made from a patented type of Perlit iron which possesses a very close grain, with durable running qualities.

The machines shown at Olympia have been chosen to demonstrate different methods of supporting the various components dealt with, including quick-action clamping, having a bayonet action, which is shown along with such modern devices as quickly changed arbors and collets.

Alfred Herbert, Ltd.

In a Supplement to this issue we describe some of the exhibits to be seen on the stands taken by Alfred Herbert, Ltd., of Coventry, but we do not therein mention the products of various firms, British and foreign, for which Alfred Herbert, Ltd., holds the agency in this country. One of the largest of the foreign machines is illustrated in Fig. 16, page 486. It is a Norton hydraulic crank pin grinding machine, which has been built specially to meet the needs of the motor car industry. It has a maximum swing over the table of 17in., and is made to take work from 28in. to 40in. or from 40in. to 52in. in length. The wheel is driven by a 25 H.P. motor and a 5 H.P. double-ended motor mounted within the rear portion of the base drives the oil and coolant pumps from one end and the work drive unit from the other. The left-hand work head is fixed longitudinally, but is provided with lateral adjustment and the right-hand head is longitudinally adjustable. Both work heads have large long spindles which run in bronze bearings. They are driven through silent chains from a shaft mounted beneath the table which itself derives its motion from the 5 H.P. motor already mentioned through a set of worm gears or clutch, which also acts as a brake when the motion is stopped. The work clamps in the work head are opened hydraulically against the action of long powerful springs. The traverse of the table is effected hydraulically from a piston working in a cylinder attached to the base. The grinding wheel is 42in. in diameter, and has a width equal to that of the pin ground. All the controls are interlocked.

Two other grinding machines, from the many to be seen on the stands, are illustrated in Figs. 17 and 18. The first is a centreless machine made by Arthur Scrivener, Ltd., of Birmingham. It is fitted with a grinding wheel 12in. diameter by 3in. wide, and a control wheel the same width and 7in. in diameter, and, with new wheels, will deal with work up to 2½in. in diameter. Three grinding wheel speeds are obtainable besides a direct drive from the motor for dressing the wheel. The grinding head is fixed. For truing two diamonds are mounted one on each side of an arm, which is lowered into position to grind both wheels together. Its arm is adjustable for the dressing of wheels for grinding tapers. Pre-loaded roller bearings carry the control and grinding spindles.

The other machine—Fig. 18—is an automatic internal grinding machine made by the Heald Machine Company, Ltd., of the United States. The work head and work reciprocate with the main table,

[21] The early stage in the expansion stroke in high-speed engines often shows an approach to isothermal expansion.

[22] "Proc.," Inst. Automobile Engineers, March, 1925, p. 649.

and the wheel head is mounted on a cross slide for sizing, which is hydraulically controlled. Once the machine has been set, the operator has only to place each work piece in the chuck and start the machine.

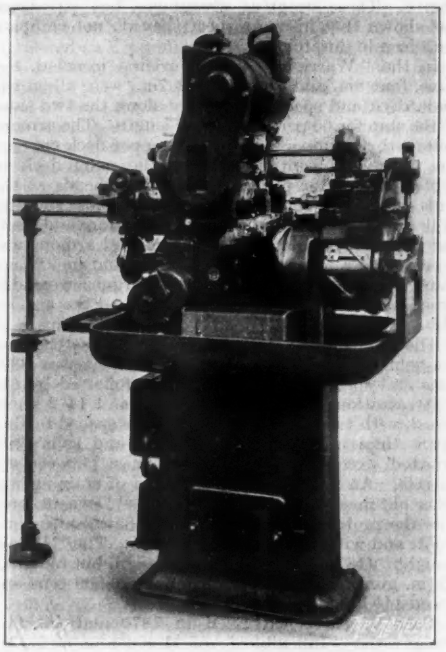


FIG. 13—HIGH-SPEED AUTOMATIC—BROWN AND WARD

The rest is done automatically according to a fixed cycle. First, the work approaches the wheel rapidly and the wheel recedes as it is about to enter the hole. A little later the wheel makes contact with the work in what might be called a plunge cut. This arrangement has the advantage that the chance of the corner of the wheel being broken off as it enters the work is eliminated. As soon as contact is made the rough feed is engaged and the reciprocation of the work head begins. A large amount of stock can thus be rapidly removed. At a predetermined point the feed becomes more gradual and a little before finished size is reached the wheel recedes and the work withdraws. The table speed alters to that suitable for wheel truing, the diamond drops into position, and the wheel is trued before re-entering the bore of the work with the same receding and approach action. Feed and table speed are now suitable for the finishing cut. As soon as the exact size of work has been reached, the wheel backs off as before and the table withdraws. All units go to the rest position and the operator takes out the finished job and places another work piece in the chuck. Two methods of sizing are available on the machine, known respectively as "gage-matic" and "size-matic." The latter method is the well-known one by which the diamond is set to true the wheel at a definite relationship to the finished size of the hole. Then a definite advance of the cross slide will bring the bore of the hole to the correct size. When grinding on the "gage-matic" system a sizing plug attempts to enter the hole each time the wheel leaves the back of the hole. As soon as the plug enters the machine goes to the rest position. The tool will swing over the table work 15in. in diameter and grind holes up to 3in. long and 1in. in diameter. The least diameter of bore is ¼in. Tapers up to 60 deg. can be ground.

The Brown and Ward high-speed automatic, illustrated in Fig. 13, is also exhibited on one of the Alfred Herbert stands. It has a capacity of ⅝in. by 2½in. Spindle speeds up to 6000 r.p.m. are obtainable, so that steel, brass, and other materials can be cut at appropriate speeds. These machines, of which three types are available—three-operation, four-operation, and four-operation including tapping—will perform turning, forming, knurling, facing and cutting-off operations from the cross slides and drilling, turning, threading, and tapping from the turret slide.

Edwick universal milling machines are also shown.

(To be continued.)

The Loeffler System of Steam Production.

AT a joint meeting of the Institute of Fuel and the Institution of Mechanical Engineers, held in London on Friday evening Nov. 9th, Mr. S. McEwen presented a paper entitled "The Loeffler System of Steam Production: Its Place in the Sphere of Power Generation." Elsewhere in this issue we reprint the main portions of this paper. On the whole it was well received but we cannot record that it completely escaped castigation nor can we say that in our opinion the criticism which it received was wholly undeserved.

Mr. H. P. Gaze occupied the chair and in his opening remarks said that no satisfactory method for the control of the temperature of the steam existed in the case of ordinary boilers. Complete control of the steam temperature was provided by the Loeffler system and as a consequence steam temperatures up to the limit permitted by the materials employed could be used without allowing a margin for a sudden uncontrolled rise. The steam circulating pump was undoubtedly the heart of the system and that being so he would suggest that it ought to be installed in duplicate.

Mr. Charles Erith said that the Loeffler system was a commercial success in Russia, Czechoslovakia and other Eastern European countries and he believed that within a few years its use would become universal and that the time was not far distant when it would be as difficult to sell a water-tube boiler to large producers of power as it was at present to sell them reciprocating steam engines. In that connection, he added, it was to be noted that the Loeffler patents would expire in about five years' time.

Mr. C. E. H. Verity delivered a strong attack on the figure—11·7 per cent.—calculated by the author for the increased steam consumption at 590 lb. pressure as compared with the 1900 lb. pressure obtained by the Loeffler system. He agreed that the Loeffler system would exhibit a gain but it would be considerably less than the figure indicated by Mr. McEwen. He based his argument on the fact that in making his calculations Mr. McEwen had assumed that the steam produced by the Loeffler system would be reheated and that that produced by the low-pressure plant would not be reheated. Further, the author had assumed a much higher final feed temperature in the case of the Loeffler system than in the other—392 deg. Fah. as compared with 302 deg. Fah. Both these factors affected the efficiency. He exhibited curves showing the relationship between the regenerative cycle efficiency and the number of feed heating stages on the one hand and the final feed temperature on the other. Mr. Verity further demonstrated by means of an entropy-total heat diagram that the conditions assumed for the Loeffler system would result in an exhaust of higher wetness than that given by the low-pressure system. Making allowances for all these factors he concluded that on a strictly comparable basis the author's figure should be reduced to 7·6 per cent. if a straight cycle were taken as the basis of comparison and to 5·9 per cent. if a reheat cycle were assumed. From the increased wetness of the exhaust steam exhibited by the Loeffler system he argued that the adoption of reheating was inevitable if that system were used and therefore that any gain arising from the employment of reheating should not be credited to the system as an advantage. Discussing the question of flexibility in the demand on boilers he exhibited curves giving the results of tests on a water-tube boiler fired with a retort stoker. Within a period of seven minutes the output had been raised or lowered by between 215,000 lb. and 245,000 lb. per hour or by about 70 per cent. of the maximum continuous rating of the boiler. He compared that figure with those given by the author for the Loeffler plant at the Trebovice station. The change of output in seven minutes in that case amounted to 40,000 lb. of steam per hour or only 25 per cent. of the maximum rating of each unit. Drawing attention to the guaranteed thermal efficiency of 26·3 per cent. for the Loeffler boilers at Trebovice he remarked that the Electricity Commissioners' figures for last year showed that some stations in this country were attaining under normal operating conditions efficiencies of 26 per cent. or over. Under a constant load and other guarantee conditions the thermal efficiency of those stations would, he thought, be much higher. The Loeffler system would therefore have to show a much higher guaranteed efficiency than it did if it were to become a competitor with existing modern power stations. Turning, in conclusion, to the question of the quality of the feed water Mr. Verity remarked that doubtlessly, as the author had said, the superheater tubes of a Loeffler boiler, having to deal only with steam, would not be affected by dirty feed water but what, he would ask, would happen to the economiser if the boiler were fed with dirty water?

Mr. W. M. Selvey, for the most part, concentrated his attention, in a non-critical manner, upon the trustworthiness of the steam circulating pump and the auxiliary equipment. The steam pump was the crux of the whole scheme. Did the author reject the necessity for a spare steam pump? A spare feed pump would always be considered a necessity. Such pumps were at least as reliable as the steam pump and if they failed their failure would be less important than a failure of the steam pump. A house boiler was a necessity of the Loeffler system. Such a boiler provided the steam required to start the action of the main boiler plant and gave the comparatively low pressure supply used to drive the turbine of the steam pump unit. The house boiler under the Loeffler system was as essential as the house turbine provided in an ordinary station to ensure the continuous operation of the circulating pumps.

Professor G. Lomonossoff called attention to the fact that the author had dealt only with the stationary and marine aspects of the Loeffler system but that it had also been applied to locomotives. Notwithstanding the difficulties which had been encountered in the Schwarzkopff-Loeffler locomotive* the system had great advantages for railway work. The standard type of boiler was the most efficient but also the most unreliable part of the Stephensonian locomotive, especially on lines with bad water. Water-tube boilers even at pressures of about 200 lb. were still less trustworthy because of the shaking to which irregularities of the permanent way subjected them. With increase of pressure the troubles of the locomotive water-tube boiler became rapidly greater. Hence in countries in which oil-engined locomotives were impracticable there was only one way of improving the individual traction of trains in a radical manner and that was by using steam-tube boilers. There were several systems of steam-tube boiler but the Loeffler was the only one possessing sufficient flexibility to meet the fluctuating conditions of railway service. Its high flexibility was the result of the use of the steam circulating pump. On the other hand elementary thermodynamics showed that the use of a steam circulating pump was practicable only with pressures in excess of 1500 lb. Such pressures could be employed only in turbines. Hence there were only two alternative solutions to the problem: the adoption of oil-engined locomotives or of turbo-locomotives with Loeffler boilers.

Mr. A. L. Timmins congratulated the author on having prepared an apparently highly technical paper from very flimsy material. He was struck by the almost entire absence of any data supporting the author's claims and contentions. The paper, in fact, appeared to be simply a collection of superlative statements with no real evidence of any actual practical foundations. It was unnecessary to stress minor points; the fundamental features of the Loeffler design were very questionable. The system was altogether too revolutionary to inspire confidence. Radiant heat superheaters had been experimented with but as yet there was no indication that they were satisfactory from the commercial point of view. Very few were in operation in this country and repeat orders had not been conspicuous. Again the reheat cycle also seemed to be far from trustworthy judging by its very limited adoption here or abroad. In any event if the radiant heat superheater and the reheating cycle were capable of giving practical satisfaction it would seem that two of the principal features of the Loeffler system could be provided in conjunction with orthodox water-tube boilers thereby making it even harder to establish a good case for departing from well-tried practice. Continuing his criticism of the Loeffler system, he said that it was a fundamental error to assume that steam was essentially clean. One knew what happened to convection superheaters when the feed water was contaminated. One also knew that in a New York Edison turbine the high-pressure blading had been choked up solidly by sediment carried over in the steam. Obviously, then, the whole basis of design of the Loeffler system must collapse unless the feed water were treated in every way as carefully as in a water-tube boiler. He would add that high-pressure steam, by virtue of its great density, had a correspondingly high capacity for carrying impurities. He would like to know whether the boilers at Trebovice had ever been operated for any length of time on raw water. If they had, how long had they been so run and at what rating, and what was the analysis and quantity of the raw water? The experiment mentioned in the paper, extending over 2000 hours, was of very little practical value because as was well known the effects of feed water contamination often took a year or more to become apparent. Ultimate trouble from dirty feed water could not be avoided except by careful inspection and scaling both of which, apparently, were impossible in the case of the Loeffler boiler. In that connection he thought it might be remarked that in a published description of the Trebovice plant it had been stated that low-pressure boilers had been installed especially to provide clean make-up to the high-pressure circulation system and that a softening plant and a de-aerator were also in use. Proceeding he remarked that he was, in the absence of any real data, inclined to doubt the author's claim that the cost of a Loeffler boiler was less than that of a water-tube boiler, particularly when the complications of the reheater and its connections were borne in mind. In addition the whole unit had to be constructed on very substantial lines in order that it might withstand the high working pressure. Incidentally apart from the formation of scale which was bound to occur if raw make-up water were used the high working pressure and the high temperature gradient rendered still more doubtful the possibility of ensuring the safety of the furnace tubes. Con-

* This locomotive was described and illustrated in our issues of April 4th 1930 and January 30th 1931.

cluding he expressed the hope that the paper would be followed by another one in which facts and figures taken from actual practice would replace optimistic forecasts.

Mr. R. W. Allen, after expressing his admiration for the design of the steam circulating pump, passed on to the employment of Loeffler boilers on destroyers. He noted, he said, that in connection with the design for a modern vessel of that type the author said that both the space occupied and the weight would be only about half that in a destroyer equipped with boilers of the usual type. He would like to ask Mr. McEwen on what design of destroyer the comparison was based. Was it a British or a Japanese destroyer or was it, perhaps, a Czechoslovakian vessel? Would it be necessary in a destroyer fitted with a Loeffler boiler to use distilled water or could ordinary town's water, such for example as that obtainable in the West Indies, be employed without previous treatment?

Mr. T. S. Blenkinsop revealed himself as being directly interested in the commercial development of the Loeffler boiler in this country and expressed every confidence in it from the engineering and commercial standpoints. He maintained that complete power plants operating on the Loeffler system could now be installed in this country at a cost not exceeding that of an ordinary plant operating at a pressure of 600 lb. Proceeding he dwelt upon the significance of the figures given by the author for the salt concentration at which a Loeffler boiler had been operated without trouble for a long period. The figure of 35 grammes per litre was equivalent to 120 grains per gallon. In an ordinary water-tube boiler operating at 250 lb. to 300 lb. it was necessary to keep the salt concentration in the feed water down to about 100 grains per gallon while in one operating at 600 lb. to 700 lb. the salt concentration should not exceed 50 grains per gallon. To attain such a figure was difficult and necessitated the installation of elaborate and costly evaporating plant and other equipment. To go beyond it was probably commercially impossible in a modern boiler plant. The question of salt concentration, he suggested, was one of the factors limiting the pressure which could be developed in water-tube boilers just as questions of metallurgy limited the temperature of the steam which could be realised. It was one of the main features of the Loeffler system that at 1900 lb. pressure it could be operated at a salt concentration equal to that usually adopted for a water-tube boiler working at 300 lb. That fact had been fully appreciated by some important industrial works on the Continent where in some cases the make-up feed amounted to 100 per cent. Mr. McEwen had stated that a device for controlling the superheat in water-tube boilers would be a welcome extra in all installations. Such devices were now being supplied by certain makers and engineers readily paid the extra cost involved by their installation in order to gain the advantage of a constant steam temperature. The Loeffler steam circulating pump ensured the same object to a degree which, he thought, no other arrangement could equal.

Mr. McEwen, replying to the chairman, said that for eight years the winding engines at the Caroline Colliery at Vitcovice had been supplied with steam solely from Loeffler boilers, that each boiler had only one steam pump and that no necessity had been found for duplicating it. The pumps had given no trouble, but if one of them should happen to fail, or if the turbine driving it went out of action, little of a serious nature would occur. At the worst, if the failure were not immediately noticed, the superheater tubes would burst, but steam alone would escape, not water, and no damage would be done. Mr. Erith's remark regarding the life of the Loeffler patents applied only to the patent of 1923. It was quite possible that that patent might be extended. In any event there were additional subsequent patents supporting the original one which would protect the owners for many years to come. Dealing with Mr. Verity's remarks on the question of flexibility in the output of steam he asked him to state the nature of the temperature change which occurred while the output of the plant referred to was varied up and down by 70 per cent. of the rated capacity. He suggested that there must have been an accompanying vast change in the superheated steam temperature. In the case of the Loeffler plant mentioned in the paper the change of output had been accomplished without any alteration whatever in the steam temperature. As regarded the effect on the economiser of passing raw water through it no economiser manufacturer would to-day hesitate to pump water through the apparatus at such a rate as would prevent the deposition of scale. He knew that some English stations claimed an overall thermal efficiency of as much as 27 per cent. as compared with the 26 per cent. guarantee for the Loeffler equipment at Vitcovice but in the hands of English engineers and under the conditions prevailing in English stations the Vitcovice plant could have been guaranteed to show a much higher efficiency. He did not accept Mr. Selvey's statement that a low pressure house boiler was a necessary feature of the Loeffler system. The turbine of the steam circulating pump could be run by means of steam bled from the main turbine. He did not indicate in what manner the steam required to start the action of the system would in that event be supplied. He reserved his reply to Mr. Timmins and merely suggested that Mr. Timmins was one of those who allowed previously developed practice to dominate their outlook and exclude the admission of new ideas. No machine was perfect and entirely without disadvantages. The Loeffler system was not perfect as compared with a 100 per cent. perfect system but when it was compared with an ordinary water-tube boiler plant he knew of no disadvantages against it.

Progress in Naval Construction.*

By Sir ARTHUR W. JOHNS, Director of Naval Construction.

I HAVE taken as the basis of this paper the progress in naval construction during the past sixty years, the approximate period covered by the professional career of the worthy founder of these lectures. If the Navy List for 1874 is consulted, it will be found that the number of combatant ships was about 350, practically the same as at present. The displacement tonnage of the fighting Navy of 1874 was 325,000, as compared with the present 1,275,000, an increase of slightly over 50 per cent., while the total indicated horse-power of the engines was 590,000 as against the present 9,500,000 S.H.P. Of the 350 vessels of 1874, 85 were iron ships, 39 were of composite construction, the rest were of wood. Twin screws were fitted in 75, mostly small ships; paddle wheels in 28; one—the "Waterwitch"—was hydraulically propelled; and the large majority of the remainder were fitted with single screws. There were still a few of the old sailing ships of the line in existence. The paddle wheel steamers were generally used as yachts or despatch boats and presumably these attained greater speed than the screw ships. All but a few ships were fitted with masts and sails, the engines being a secondary rather than a primary means of propulsion.

The classification of these 350 ships was very different from that with which we are familiar, and in fact the only class which we have still is the sloop, although it signified a different vessel from that now so termed. There were 48 sloops, 33 corvettes, 28 frigates, 55 armour-plated or armour-clad ships, 11 armour-plated turret ships, 36 gun vessels, and 70 gunboats. Of the remainder, and classified simply as "ships," were 20 of the old line-of-battle ships mounting from 70 to 102 guns—as if some old sea dog at the Admiralty had decided that these were the real "ships," the rest were of little account. On the stocks at the time were two notable vessels, the "Fury" (afterwards "Dreadnought") of 11,000 tons, laid down in September, 1870, and completed in 1879, and the "Inflexible" of 11,160 tons, laid down in February, 1874, and completed in October, 1881. The former is classed as "Turret ship armoured plated," and the latter an "Iron turret ship armour plated." The "Fury" was designed by Sir Edward Reed and the "Inflexible" by his successor (1870), Sir Nathaniel Barnaby.

* From the third Andrew Laing Lecture, North-East Coast Institution of Engineers and Shipbuilders, November 2nd.

Materials of Construction.

The 1874 Navy List carefully distinguishes the ships built of iron, as if it were novel or singular, although the material had been used in the mercantile marine for several decades. The naval authorities—not only here but in other countries—had been very loth to accept iron in place of wood, as the material of construction of warships and some iron ships ordered by the Admiralty in 1845 were condemned for their intended service almost before completion. The composite ship, patented by Ditchburn in 1841, with its wooden bottom planking and iron frames, was not so objectionable and was used for the smaller gun vessels.

Some designs submitted for our first sea-going armourclad—the "Warrior"—were for a wooden hull, but it was decided in 1859, not without considerable discussion, that she should be built of iron. Wood was displaced finally and some wooden warships then on the stocks were completed with iron upper decks and topsides. The "Inflexible" laid down in 1874 was the first in which steel was used, the vertical keel and the longitudinal frames, except the armour shelf, being of this material. The armour shelf was of iron, experiment having shown that against projectiles steel was inferior. The whole of the inner and outer bottom and deck plating was of iron (BB quality).

There was apparently a little trouble with the steel then supplied, for my predecessor, Sir Nathaniel Barnaby, admonished the steel makers on at least two occasions at the Iron and Steel Institute on the shortcoming of their products and expressed the hope that they would improve them in the future. The length of plates which can now be supplied for shipbuilding are from 36ft. to 40ft., as compared with the 12ft. for iron and 16ft. for steel of the "Inflexible." The breadths have also increased, but not to the same degree. These are great advantages, but experience has shown that in one respect they do not compare with iron in durability.

In the "Warrior" (1859), our first ironclad, the guns, four 8in. and twenty-eight 7in., were all on the main deck and spaced uniformly along the two sides of the ship for 60 per cent. of her length. The armour belt with its upper edge at the upper deck covered the guns, and continued below the main deck to protect the water plane. Armour bulkheads at the ends of the belt completed the protection. The arcs of fire of the guns were a few degrees before and abaft the beam. This disposition of guns and armour was repeated in a few succeeding vessels, and in "Minotaur" and "Agincourt" (1861) the guns were disposed along the whole length of side and the armour also. The type was termed "broadside" ships.

The "Monarch," designed by Reed, was the first sea-going turret ship. Her displacement was 8300 tons and speed 15 knots. She was followed by the "Devastation" (1869) of 9200 tons and 14·2 knots speed, with two twin 12in. gun turrets spaced further apart than in "Monarch." Masts and sails were omitted, except for a "military" mast between the turrets. An unbroken and wide arc of training was thus obtained by the latter. The "Devastation" was the prototype of the numerous battleships since built, and with which we are familiar. The "Dreadnought" (1870) was of the same design, but mounted 12½in. guns, the displacement being 10,800 tons and speed 14½ knots.

Barnaby succeeded Reed in 1870 and his first design—the "Inflexible"—of 11,900 tons and 13·8 knots speed, was a very distinct departure from the "Devastation." The armament was four 16in. guns mounted in two turrets placed *en echelon* in the waist, the belt armour being 24in. thick in place of 12in. in the "Devastation." These large increases in weight limited the belt to one-third the ship's length, the waterplane before and abaft being protected by cofferdams, cork and coal. In the "Nile" and "Trafalgar" (1886) the arrangement of the "Devastation" was reverted to, the belt not being of full length, but sufficient to protect the most effective portion of the waterplane. Until 1905 our battleships followed this same general type, although many minor improvements were effected, and the speed, protection, sea worthiness, and armament—both main and auxiliary—increased. In 1905 came the "Dreadnought," of appreciably greater tonnage than her predecessors and with five twin 12in. turrets. Succeeding ships varied in the disposition of the main armament and armour, but as now represented in the Navy by the "Royal Sovereign" and "Queen Elizabeth" classes, the type is not very different from the "Devastation" of 1869. "Nelson" and "Rodney," with their three triple turrets grouped together forward, are a departure from this general type, but have their prototypes in "Conqueror" and "Hero" (1879), "Victoria" and "Sans Pareil" (1885), with a single turret forward and a blind arc aft, the two latter having one 10in. gun in the stern to cover it. The battle-cruiser, introduced with the "Dreadnought," is a type in which in the earlier examples superior speed to the battleship was obtained by a diminution in protection. After several different dispositions of the main armament, the latest representation—the "Hood"—has reverted to the orthodox.

Cruisers.

In the cruiser type there has been less scope for variations in the calibre and disposition of the guns than in capital ships. From about 1880 the usual armament for cruisers was a medium calibre gun, 9·2in., 8in., or 6in., on poop and forecastle, with 6in. or 4·7in. guns on the upper deck on either broadside, but there have been slight variations, some of which will be noticed. The method of protection has varied with the times, the earliest large cruisers being armoured on the sides, and the smaller fitted with a protective deck of arch form, the edges being well below and the middle well above the water line, with coal bunkers at the sides of the ship, both above and below this deck. The first-named type were termed "armoured" and the second "protected" cruisers. A noticeable difference between the earlier cruisers and those built shortly before and during the war is in the position of the guns. In the former one gun was fitted on the middle line forward and one aft, the remainder being on the upper deck and equally divided on the broadsides. In the later ships all the guns are on the middle line, those in the waist a deck higher, and they can train on either broadside. In the newest cruisers the armament has been forced to the ends, as with the main armament of capital ships. The speed of cruisers has increased gradually from 14 knots in 1874 to 32½ at present, the horse-power of "Nelson" (1874) being 4500, as compared with 72,000 in our latest cruisers of the same displacement.

Torpedo Vessels.

Amongst the 350 active service vessels in the Navy of 1874, armed with guns varying from two in the gun vessels to 107 in the "Royal Albert," a wooden line-of-battle ship, was one vessel, the "Vesuvius," the

forerunner of the hundreds of flotillas of torpedo-boats, destroyers, and leaders which have since been built. She is designated a "double-screw iron torpedo vessel" of 240 tons and 350 H.P. Designed by the Construction Department of the Admiralty, she was ordered to be built on February 12th, 1872, laid down at Pembroke on March 16th, 1873, and completed on September 11th, 1874. Her dimensions were:—Length, 90ft.; beam, 22ft.; and mean draught, 7¾ft.; her designed speed was 10 knots and speed on trial 9·8 knots with 380 I.H.P. Her armament consisted of ten 16in. torpedoes about 14ft. long with a charge of 67 lb. of guncotton. These were discharged by air pressure from a fore-and-aft submerged tube low down in the bow, about 2ft. in diameter and 19ft. long, fitted with a sluice valve 4ft. from the forward end, and with side guides and ten rollers top and bottom. This vessel remained in the service until 1923, when she was sold for breaking up. Her life of nearly fifty years is a striking tribute to the quality of the iron used in her construction. Other torpedo vessels had been completed before by Messrs. Thornycroft and Messrs. Yarrow, but these were generally of smaller type for use with spar torpedoes or for towing them; she was the first built with tube discharge, and yet not the first to be fitted with a tube, for amongst the harbour service vessels in the 1874 Navy List is the "Oberon," described as "late Paddle Steam Vessel" used by the War Department for torpedo experiments. Whitehead, of Fiume, had, after numerous experiments, developed by 1868 an automobile torpedo, and in May, 1870, arrived in England with a dozen torpedoes of 16in. and 14in. diameter and a tube which he had designed for discharging them.

Following on the recommendation of a Committee, the "Vesuvius" was designed, and several of the largest ships then in commission were fitted with torpedo tubes, the "Warrior" in 1873, "Achilles" 1875, "Glatton" 1875, "Agincourt" 1876, "Northumberland" and "Hercules" 1877, and "Monarch" 1878. The tubes in these ships were submerged, placed transversely, and fitted with a sliding projecting U-shaped bar on the fore side which prevented the torpedo from being deflected when discharged. In 1875 further experiments were carried out to ascertain if it were practicable to discharge torpedoes from tubes above the water and with the ship moving at high speed. For this purpose H.M.S. "Shah" was fitted with a tube projecting through one of its gun ports and 12ft. above water. The experiments showed that from this height discharge could be satisfactorily effected at 14 knots, the highest speed of the ship. In the same year a protection against the torpedo was secured by the construction of a torpedo net.

By the end of 1888 the Navy had 100 first-class torpedo boats, the length and displacement having increased from 55ft. to 125ft. and 30 to 100 tons respectively, with speeds of 20 to 21 knots. These all carried 14in. torpedoes, the earliest being fitted with dropping gear, some with fixed troughs on the bow for ejecting the torpedoes, while others had fixed deck tubes. In 1885 revolving deck tubes were first fitted.

An interesting vessel described as a "Torpedo-ram" was the "Polyphemus," laid down at Chatham in September, 1878, and completed four years later. Of 2640 tons displacement, 5500 I.H.P. and 18 knots speed, fitted with five submerged torpedo tubes, one in the bow and two on either broadside, and carrying eighteen 14in. torpedoes, she was intended to ram or torpedo an enemy vessel. She was provided with ballast tanks to enable her to submerge until the weather deck was nearly awash, and, if damaged, ballast housed in the keel and readily detachable could be let go to restore her buoyancy.

The number of torpedo boats in the various navies had rapidly increased in number, and in 1892 Lord Fisher, then Controller of the Navy, was informed that the French were contemplating the construction of a type of craft which would be superior in speed and armament to torpedo boats. Yarrow was consulted by Fisher and expressed the opinion that British shipbuilders could design and build faster and more powerful vessels than the current type of torpedo boat. As a result orders were placed with Messrs. Yarrow and Thornycroft in June, 1892, and a little later with Laird, for two vessels each. These were the first torpedo-boat destroyers for the British Navy. Intended as an antidote to torpedo boats, they have since taken their place, and the vessels they were intended to destroy have disappeared from our Navy. Their cost was about £40,000 each.

The armament has progressively become more powerful. In 1908 the 4in. gun replaced the 12-pounder and in 1918 the former gave way to the 4·7in. In 1908 21in. torpedoes replaced the 18in. In 1913 four torpedo tubes were fitted in place of two, in 1916 six instead of four, and in 1917 eight instead of six.

In 1913 a slightly larger and faster vessel than the ordinary destroyer was introduced into the British Navy, its function being to act as the flagship of a flotilla of destroyers. It was and is still termed a destroyer leader.

Displacement, speed, endurance, calibre of guns, and number of tubes, have since gradually been augmented, until at the present time destroyers are of 1375 tons, with 36,000 S.H.P., 35½ knots speed, and carry four 4·7in. guns and eight torpedo tubes. Their cost is approximately £300,000, compared with £40,400 for their prototype of 1874. Leaders mount five guns, are half a knot faster, and are of about 100 tons greater displacement. By the London Treaty, signed by the British Empire, the United States and Japan, the standard displacement of destroyers is limited to 1500 and that of leaders to 1850 tons, the calibre of gun not to exceed 5·1in. France has during the past few years built vessels of this type of a displacement of 2450 to 2570 tons with 37 knots speed, armed with 5·5in. guns and virtually light cruisers.

Submarines.

The first submarines for the British Navy were ordered at the end of 1900, but such vessels had been built and used in naval warfare before then. One designed by the American Bushnell attacked the "Eagle," a British warship, in New York harbour in 1775. The submarine reached the side of the "Eagle" and her crew proceeded to bore a hole in her planking to attach a mine. The copper sheathing prevented this, but the mine was slipped and exploded some distance away. In 1801 a submarine designed by Fulton succeeded in placing and exploding a mine under a target ship. In 1864 during the American Civil War the "Housatonic" was sunk by a spar torpedo placed against her side by a submarine which also sank by the explosion. These earlier submarines were practically blind when submerged, but the invention of the periscope in 1865 removed this defect, while the automobile torpedo (1870) offered a more effective and more easily operated weapon than the charges hitherto used. Later the internal combustion engine facilitated the problem of surface propulsion which had previously been attained by steam or by batteries and motors.

As with the early torpedo boats in Kipling's "Their Lawful Occasions," the value of the submarine as a weapon of war was not greatly appreciated at the outbreak of the Great War, and this perhaps accounted for some of our early mishaps. This soon changed, and Lord Fisher, at the time First Sea Lord, in November, 1914, ordered a large number, twenty from America—termed H type—and thirty-eight E class from many British firms. Statistics indicate that amongst the numerous types of vessel which were engaged in combating the submarine menace the submarine was the most effective.

The ordinary submarine engine has increased in power from 1200 H.P., reached during the war, to 2200, as in the "Rainbow" class. The weight per B.H.P. has decreased slightly, but the chief gain is in the length occupied in the submarine, which shows an appreciable decrease, permitting the length and displacement of the vessel to be correspondingly reduced. Speeds, both surface and submerged, remain practically the same as during the war. An increase in submerged speed is difficult to obtain with the present secondary batteries and motors, the heaviest system employed in warship propulsion. The weight of the battery alone is in the region of 200 lb. per B.H.P. developed by the motors, and although attempts have been made to reduce this figure and also the space occupied in the submarine, little progress in this direction has resulted.

There is one feature in later submarines to which reference must be made, and that is in the provision which has been made for the escape of the officers and men from a sunken submarine.

Stability and Strength.

We are now so well acquainted with the problems of stability and strength of ships that we are apt to forget that this knowledge has only been acquired during the past sixty or seventy years. Stability had been the bugbear of naval architects since the thirteenth or fourteenth century, when mariners first practised the art of sailing on a wind. Experience had shown that an addition of ballast, or an increase in beam by girdling, improved the stability of a "walty" or "tender-sided" ship, but none could give the reason. In 1746 Bouguer, a French mathematician, defined the metacentre and explained how its position was determined. Admiral Chapman (1721–1808), the famous Swedish naval architect, was the only one to recognise the value of the metacentre in the problem of stability, construct metacentric diagrams, incline his ships, and determine their metacentric heights. The stability of our warships was notoriously bad during the eighteenth and well into the nineteenth century, but neither Bouguer's nor Chapman's work was utilised by our naval architects. Atwood, a mathematician, in a paper presented to the Royal Society in 1798, proved to his own satisfaction that the metacentre was a mere mathematical curiosity, useless to the naval architect, and gave us his wedge formula for stability. In 1832 a British warship was inclined to about 3 deg., and the position of the centre of gravity determined by using Atwood's method. In 1855 a second warship was inclined and the same method used. As a matter of curiosity Barnes, an English constructor, drew the line of action of the buoyancy at the inclination reached, and to his surprise it intersected the line of action when upright in a point which coincided with the metacentre calculated by Bouguer's method. This was found to apply at larger angles also, and thus about 1860 the metacentre and the metacentric height were adopted to express the stability for inclinations up to 10 deg. or 15 deg.

In 1871 the "Captain," a turret ship fitted with masts and sails, capsized with great loss of life. The investigations into her loss showed the effect of freeboard on the height and range of the curve of stability, while the curve of dynamical stability gave some measure of the safety of a sailing ship struck by a squall. The value of freeboard was also emphasised by the loss of the "Eurydice" in 1878, when water entered an open lee port as the vessel lurched when a squall struck her sails. At about this time White and John made those investigations which resulted in a marked advance in our knowledge of the stability of a ship, and of the features which improve or adversely affect it. In 1877 it was ordered that a stability statement giving the metacentric heights and range of stability for various conditions should be supplied to every British warship. The omission of sails has to a great extent simplified the problem, and it is rare now to hear of a ship having insufficient stability.

The metacentric height of a fast vessel under way, when the configuration of the water around her is very different from when at rest, has been experimentally studied at the Froude Tank. The stability of a planing boat when it stands nearly on its stern is a problem on which as yet there is no information.

Strength calculations were not made for wooden warships whose weights were fairly evenly distributed and whose load diagram must have been very low and uniform in still water. The ships were short, and even amongst waves the straining actions were not excessive. Rigidity was less than in an iron or steel ship, and on undocking a wooden ship a break of 12in. to 18in. was not unusual. This was greatly reduced by the fitting of diagonal riders, introduced towards the end of the eighteenth century. The earliest iron warships with their armament and armour disposed uniformly along the length, were not greatly different in this respect from their wooden predecessors. Strength calculations were made for them, but were simple and based on those for a trussed girder, *i.e.*, the upper deck plating and sheer strakes were taken as the top member and the double bottom as the lower member of the girder, the structure between being disregarded. The bending moment was that with the vessel grounded and unsupported for a certain portion of her length.

Such calculations were sufficient for these earlier iron warships, but as the type developed into the "Monarch" and her successors, with a very marked concentration of weight amidships in the two heavy turrets, the citadel armour, machinery and boilers, the problem of strength required more elaborate treatment. It was then that Reed sought the assistance of Fairbairn, and the two established the calculations which assume the ship poised on a crest or the hollow of a wave of its own length and with a height of proportionate amount, and treated the whole structure as a homogeneous beam. Shearing stresses were not calculated, and it was some years later before it was shown that these might also be important. By such calculations certain figures for stress in the deck and keel were determined, and extended sea experience with many types of ships served as a guide to the value which might safely be accepted. It was recognised that such values might not be the actual stresses in the structure, and were comparative only. Experiments with actual vessels subjected to known loadings have since been made, and these tend to show that the actual stresses in a ship's structure are approximately the same as those determined by the standard methods and calculations. Observations at sea show that the highest deck stresses are generally less than the calculated.

AMERICAN DUPLEX PROCESS FOR CAST IRON.

A cast iron which meets the exacting requirements for railway carriage and wagon wheels has been produced in America, although steel wheels of various kinds are also used extensively. As the loads on wheels have steadily increased, so the quality and character of the cast iron have been improved in order to keep pace with new conditions. The wheels as now used have chilled treads of great hardness, to resist wear, while the body of the wheel is of hard and tough metal qualified to resist shocks. The two million goods wagons now equipped with such wheels, or 16 million wheels in all, travel an average of 10,000 miles annually and the average load is 6 tons per wheel. One of the latest developments is the manufacture of car wheel iron by a combination of a hot-blast cupola with a hot-blast air furnace. While no change in chemical composition is made by the air furnace, the physical properties are improved 10 to 20 per cent., owing to the superheating, with removal of non-metallic inclusions and the deoxidation and degasification of the metal. This heating of the metal, before pouring, to about 2900 deg. Fah., produces an extremely homogeneous metal. The 74in. cupola has a melting rate of 28 tons per hour and is served by a battery of three reheaters in series. Coke is about 159 lb. per ton of iron, and the blast pressure is about 8 oz. In the continuous process molten iron from the cupola flows in a trough to the air furnace 7½ft. by 40ft., of 30 tons capacity. Through this the iron flows against the direction of flame and hot blast, and then passes out to a trough discharging into a tilting ladle. Pulverised coal is blown directly into the furnace through water-cooled nozzles, and instead of being fed from bunkers it goes immediately from the pulverising plant to the furnace. Its fineness is such that 98 per cent. will pass a 200-mesh screen. This plant produces 400 wheels per eight-hour shift.

High Rupturing Capacity Fuses.

No. IV.

(*Continued from page 457, November 9th.*)

CARTRIDGE fuses for heavy short-circuit A.C. and D.C. duty have been designed and subjected to exhaustive breaking capacity and fusing current-time tests by the Metropolitan-Vickers Electrical Company, of Trafford Park, Manchester. Three standard sizes of fuse carrier are manufactured suitable for systems working at pressures up to 650 volts. The maximum current ratings of the three sizes are 100, 200, and 400 ampères respectively, but any size of carrier can be wired for normal load currents as low as 5 ampères. All the fuses have an assigned short-circuit breaking capacity of 20,000 kVA at 650 volts, 50 cycles, based on tests with equipment (Fig. 31) consisting of a 10,000-kVA, 6600-volt, three-phase generator connected to a 1000-kVA

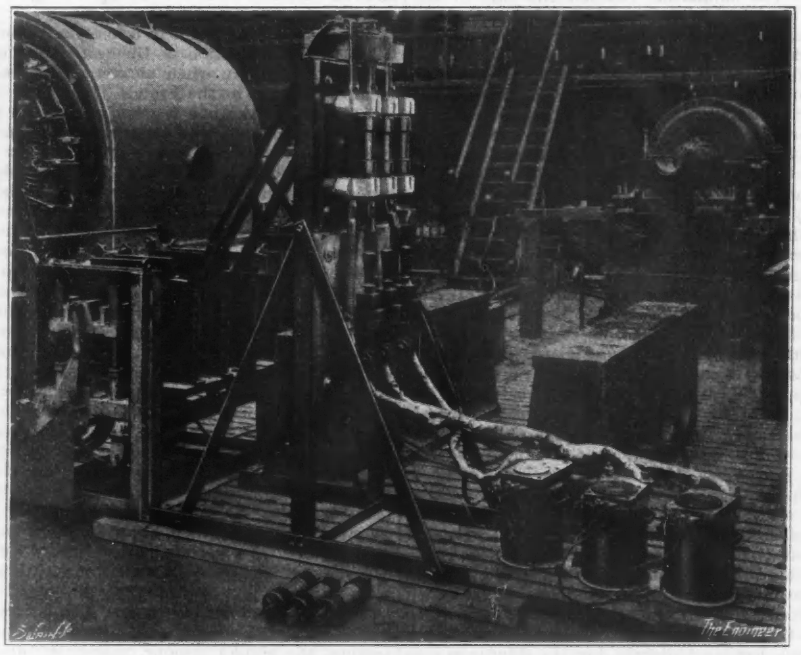


FIG. 31—FUSE TESTING EQUIPMENT

6400/405-volt, three-phase, delta/star connected transformer. In the three-phase tests a set of three fuses formed a star connection across the low-voltage terminals of the transformers. In the single-phase tests one fuse was connected across the outer terminals of the transformer. A remote-controlled master switch connected in the low-voltage circuit was employed to apply the short-circuit for each test. Typical oscillograms* are given in Figs. 32–34, and a table of test results relating to a 400-ampère fuse wired for various normal load currents is reproduced in the next column.

As a typical example of the short-circuit performance on a D.C. system, a 200-ampère fuse having a silver element was connected on the D.C. side of a 2000-kW, 500-volt rotary converter, and a short circuit was applied. As shown in the oscillogram, Fig. 34, the fuse successfully cleared a current of 20,000 ampères, corresponding to a D.C. short circuit of 10,000 kW at 500 volts. Another fuse with a copper element successfully cleared 17,900 ampères, the arcing times being 0·01 and 0·0073 second respectively.

For normal load currents up to 20 ampères the fuse element consists of tinned copper wire, whilst for larger current ratings soft-tinned copper strips are employed. As shown in Fig. 35, copper elements require a minimum fusing current of approximately 200 per cent. of the normal load current, whilst silver elements, which are naturally more expensive, operate with a fusing current of 150 per cent. In all cases the fuse elements are clamped in position and the rewiring of a fuse is a simple operation, which can be carried out without the aid of special tools.

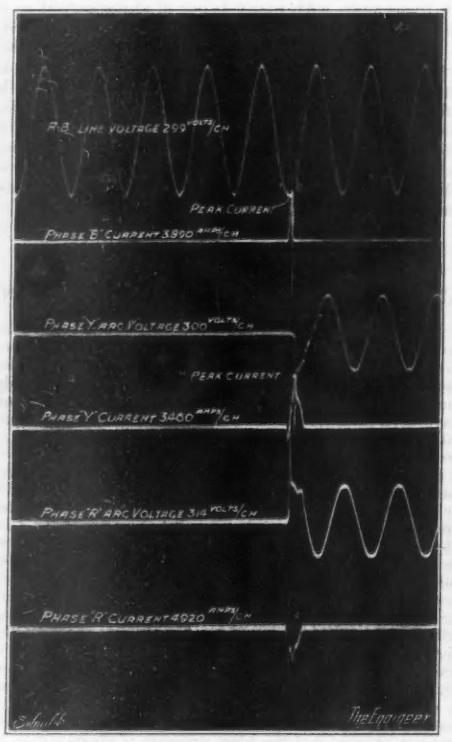

R.B. LINE VOLTAGE 299 VOLTS/CM
PEAK CURRENT
PHASE B CURRENT 3890 AMPS/CM
PHASE Y ARC VOLTAGE 300 VOLTS/CM
PEAK CURRENT
PHASE Y CURRENT 3480 AMPS/CM
PHASE R ARC VOLTAGE 318 VOLTS/CM
PHASE R CURRENT 4020 AMPS/CM
The Engineer

FIG. 32—OSCILLOGRAM OF A.C. TEST ON 10-AMPERE FUSE

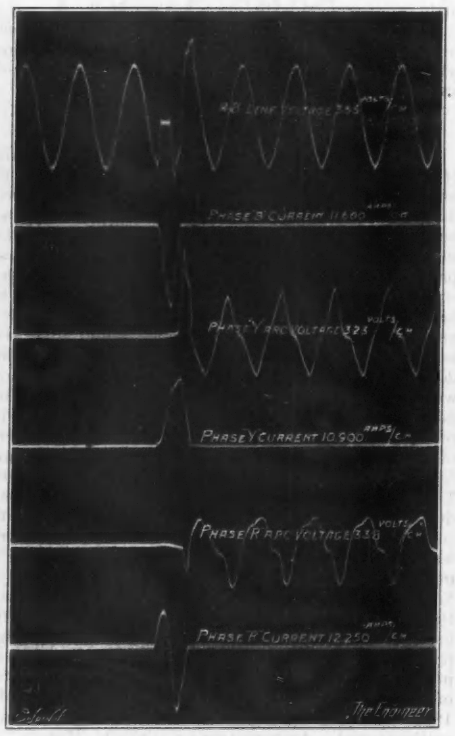


FIG. 33—OSCILLOGRAM OF A.C. TEST ON 200-AMPERE FUSE

* Reduced in the ratios 1·75—1, 1·67—1, and 1·54—1 respectively.

Line volts, R.M.S.	Normal rating of fuse.	Phases.	Maximum peak currents.	Total time in seconds.	Oscillogram Fig. No.
372	10 amp.	Red Yellow Blue	4,600 7,000 3,940	0·0077 0·00345 0·0077	Fig. 32
350	100 amp.	Red Yellow Blue	17,800 16,400 8,120	0·008 0·00534 0·0087	
362	200 amp.	Red Yellow Blue	20,800 20,200 25,500	0·0117 0·0127 0·0086	Fig. 33
356	400 amp.	Red Yellow Blue	28,100 36,000 25,400	0·044 0·012 0·044	

Two examples of these high-rupturing capacity fuses are shown in Fig. 36. The fuse carrier consists of a special fibre tube dimensioned on the basis of tests designed to check the thermal rating and to obtain a very high ratio of volume of filling powder to that of the fusible element, in order to obtain a high short-circuit breaking capacity.

The filling powder surrounding the fuse element

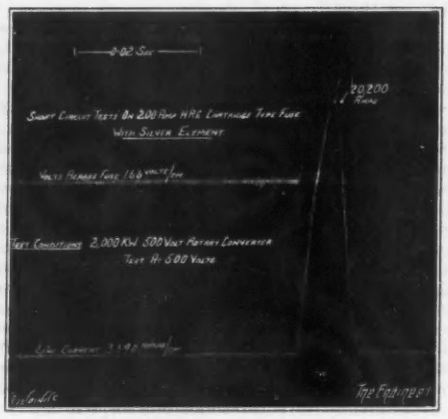


FIG. 34—OSCILLOGRAM OF D.C. TEST ON 200-AMPERE FUSE

(Fig. 37) consists of a mixture of inert powders, which quench the arc and act as a cooling medium. Under operating conditions ejection of the powder is prevented by pads of asbestos wool and baffle plates at the ends of the fuse underneath the main end caps. An asbestos lining inside the fuse tube protects the carrier from damage owing to the spreading of metal from the element during its destruction. The

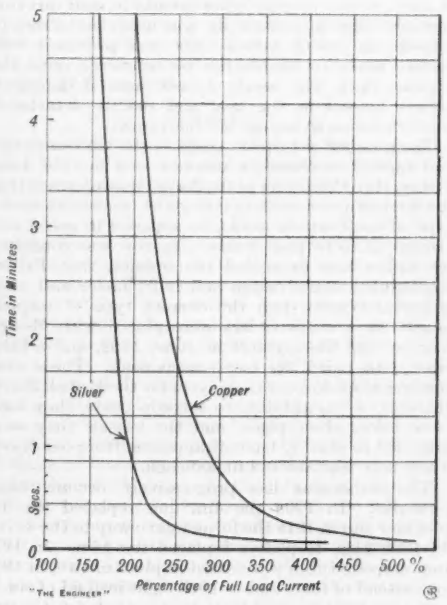


FIG. 35—TIME-CURRENT CURVES

construction of the fuse contacts and that of the jaws which receive them is apparent from Fig. 36. If required, shrouds of insulating material are supplied to enclose the fuse contacts and metal caps in the case of 400-ampère fuses. Fuse elements, filling powder, &c., are supplied to the user with instructions for rewiring, which is quite a simple operation.

High-voltage outdoor fuses are made by the Metropolitan-Vickers Electrical Company for dealing

with such troubles as transformer failures and short circuits between high-pressure lines. Of the two types available, the "F" type, shown in Fig. 38, is the less expensive. The fusible element within a glass tube terminates at each end in lead caps, which are

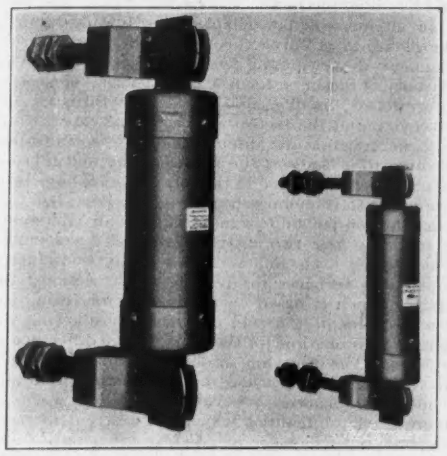


FIG. 36—CARTRIDGE FUSES

gripped by clips mounted on standard pin insulators, which also carry arcing horns, as shown. When the fuse blows, the glass is broken and the arc is transferred to the horns. The glass tube serves to protect

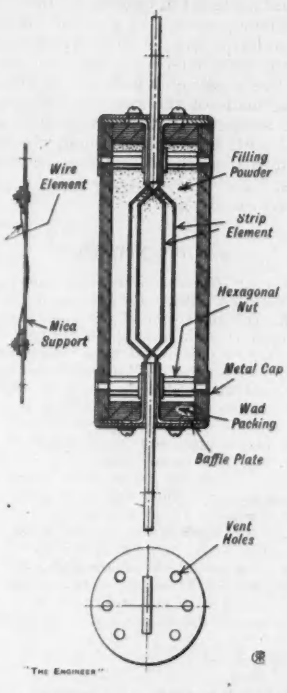


FIG. 37—DETAILS OF CARTRIDGE FUSE

the fuse wire from corrosion and the complete fuse is easily replaced. The fuse element is supplied for various currents up to 50 ampères, the voltage rating of the fuse shown in Fig. 38 being 37 kV. For use

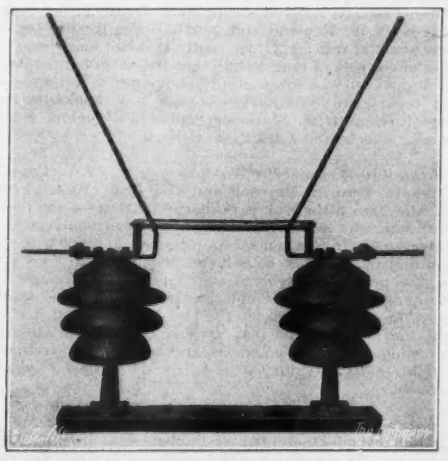


FIG. 38—37-KV FUSE

where arcing space cannot be provided for the horns, or where the short-circuit currents may be very severe, a carbon-tetrachloride or spring operated fuse, as described in the first article, is supplied. In this case the fuse element cannot be mounted horizontally, but must be placed at an angle not exceeding 45 deg. from the vertical.

Three forms of mounting are employed. The inverted type (S C I), Fig. 39, in which the fuse is held below the insulators; the upright type (S C U), Fig. 40, in which the fuse is above the insulators; and the vertical form (S C V), Fig. 41, in which the fuse is held by insulators mounted at an angle. Standard interchangeable insulators mounted on galvanised channel steel base are employed in each case. The fusible element of the carbon-tetrachloride fuses is more expensive than that of the "F" type

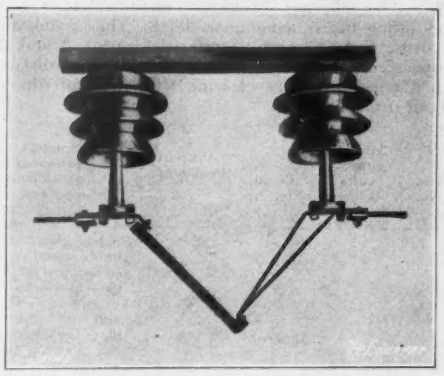


FIG. 39—INVERTED TYPE FUSE

fuse, and after the fuse has blown it can only be refilled at the factory. As there is no open arcing, however, ordinary conductor clearances may be adopted. The fuse units can be supplied for various current capacities up to 200 ampères. All the fuses are made for B.S.I. voltage ratings of 6·6, 11, 22, 33, 44, and 66 kilovolts, the maximum voltage ratings being 7·5, 15, 25, 37, 50, and 70 kV respectively.

A fuse developed by Ferguson Pailin, Ltd., of Higher Openshaw, Manchester, is particularly suitable for the protection of potential transformers used for the operation of instruments and protective

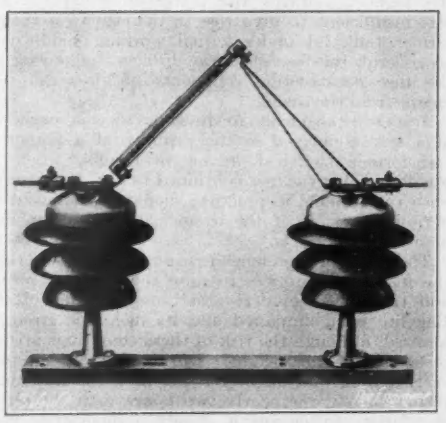


FIG. 40—UPRIGHT TYPE FUSE

gear. The performance of the fuse on test indicates that it may also be employed for the protection of very low-power tappings from E.H.T. lines, which may thus be made to provide very small power demands. With some of the oil-immersed fuses provided in the tanks of potential transformers the minimum fusing current may permit a large amount of energy to be liberated. A very low fusing current is desirable to limit and interrupt the energy; in fact, the value of the fusing current should be the lowest possible consistent with the capacity of the fuse to carry normal currents continuously without deterioration. A small section of conducting material must therefore be employed, but unless an automatic or spring-loaded device is incorporated, the fusible link must be of considerable length on account of the high recovery voltage available when the circuit is broken. But when spring-loaded devices are adopted, the fusing current is generally limited by the section of the wire necessary to withstand the spring pull, and the minimum value is usually in excess of 2 ampères. Unless electrostatically shielded to avoid the formation of corona, the fusible element, usually consisting of a fine wire, is very liable to deteriorate.

These difficulties are overcome in the Ferguson Pailin fuse, Fig. 42, by the use of a long tubular bulb or "lamp," to support the fuse element, which

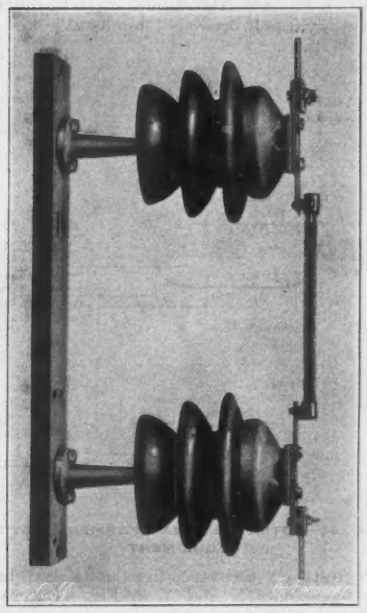


FIG. 41—VERTICAL TYPE FUSE

takes the form of a very fine wire having a suitable inherent resistance. The "lamp," Fig. 43, is electrostatically shielded by a Bakelite bushing, which also acts as an insulator of the condenser type when the circuit is broken. Between the terminals of the fusible element for 22/33 kV the clearance is nearly 10in. in oil, and the standard values of minimum

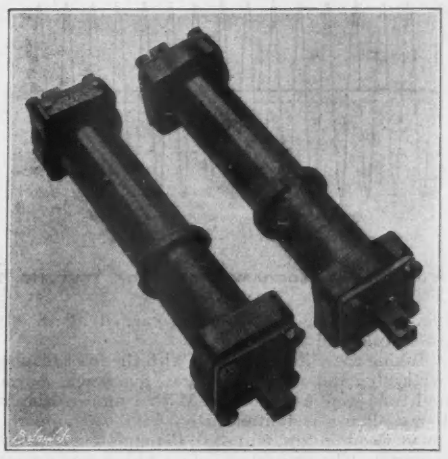


FIG. 42—POTENTIAL TRANSFORMER FUSES

fusing current obtained are less than 0·5–0·9 ampères. But although the fusing current is low the fuse will carry any reasonable overload which is likely to be met with in practice. At each end of the tubular bulb there is a vent, and when the fuse is in service oil enters through the vents and fills the tube.

Tests show that the circuit is interrupted in about one-quarter of a cycle, and in consequence of the very small amount of metal in the fuse element the short-circuit kVA is limited. Part of the metal is volatilised by a small amount of energy, and forms an arc, the effective resistance of which is greater than that of the corresponding part of the element prior to volatilisation. Hence, an arc of high power cannot develop and the low arc energy is rapidly destroyed. The limitation of the short-circuit

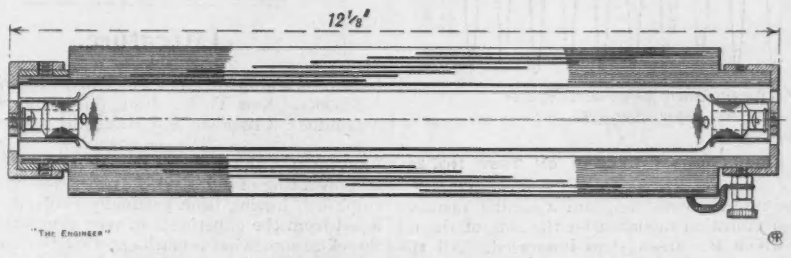


FIG. 43—SECTION THROUGH POTENTIAL TRANSFORMER FUSE

kVA to be broken, and the short time required for fault clearance, results in a minimum amount of energy being released in the transformer tank. When an external resistance is connected in series with the fuse the effect is to reduce the short-circuit current and the severity of circuit-breaking still further.

The equipment employed for testing these fuses is shown in Fig. 44. The output of the testing transformer was variable between 7 and 38 kV. For short-

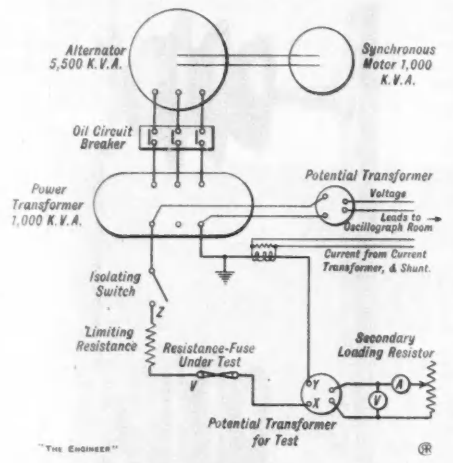


FIG. 44—POTENTIAL TRANSFORMER TESTING EQUIPMENT

circuit tests on resistance-fuse units and limiting resistance, points X and Y in Fig. 44 were short circuited, whilst for tests on resistance-fuse units alone, as in the majority of cases, X was connected to Y as before and Z to V. The tests were made to determine the following points:—(1) Fusing time-current characteristics; (2) effect of warm oil—high voltage and mechanical vibration simultaneously—(3) effect of very hot oil; (4) rupturing ability, and (5) effect of current slightly less than the

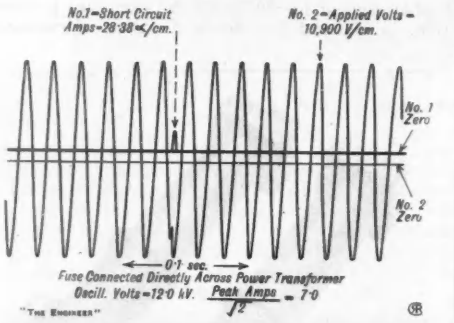

No.1—Short Circuit Amps=28·38√2/cm.
No. 2—Applied Volts = 10,900 V/cm.
No. 1 Zero
No. 2 Zero
0·1 sec.
Fuse Connected Directly Across Power Transformer
Oscill. Volts=12·0 kV. Peak Amps / √2 = 7·0
"The Engineer"

FIG. 45—OSCILLOGRAM RECORD OF TEST NO. 3

minimum fusing current being carried by the fuse for a prolonged time.

Taking these items in order with the fuses mounted vertically, the average figures for fusing current and time were as follows:—With 1 ampère the fuse blows almost instantaneously, with 0·5 ampère in about two minutes, and at 0·45 ampère in about ten minutes. The resistance before fusing was approximately 500 ohms. In the warm oil and vibration tests fuses were subjected to vibration by a violently

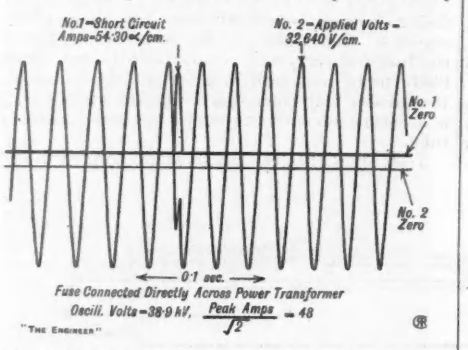

No.1—Short Circuit Amps=54·30√2/cm.
No. 2—Applied Volts = 32,640 V/cm.
No. 1 Zero
No. 2 Zero
0·1 sec.
Fuse Connected Directly Across Power Transformer
Oscill. Volts=38·9 kV. Peak Amps / √2 = 48
"The Engineer"

FIG. 46—OSCILLOGRAM RECORD OF TEST NO. 29

chattering no-volt armature, and a similar member giving less vibration mounted on the side of the oil tank in which the fuses were immersed. All the fuses were immersed in oil at a temperature of about 50 deg. Cent., and were mounted 3in. apart at various distances from the tank. They were energised from the 33 kV transformer, and the test was continued for several months, the resistance of the fine wire element being taken at intervals in order to detect any deterioration of the wire surface, but no indication of any such change was recorded.

As regards the hot oil test, sample fuses were mounted vertically in a tank of oil at 110 deg. Cent. for three months, and the effects of the hot oil were observed every three days. At the conclusion of the test resistance variation was inappreciable, and the fusing characteristics were approximately normal.

A wide range of rupturing capacity tests was covered, but particulars of one or two will suffice to give a general idea of the results. The fuse units were mounted vertically in an open tank with 4in. to 6in. head of oil, and were tested by suddenly connecting them directly to the 33 kV, three-phase, 1000 kVA transformer by means of an isolating switch operated from the control room, and timed in conjunction with the rotating film drum of an oscillograph. The results of five tests are given in the following table, in which the last test, No. 7/8 relates to an electrostatically tinfoil-shielded fuse, the other fuses being unshielded. The oscillogram records, Figs. 45 and 46, related to tests 3 and 29 respectively, show the general absence of distress when the fuses were clearing the short circuits in about 0·005 second.

Test No.	Approx. supply volts before short kV.	Oscill. Fig. No.	Current Peak amps. / √2	Phenomena observed and subsequent condition of fuse casing.
2	7	—	2·5	Slight glow, few bubbles and small emission of smoke; glass unaffected
3	12	45	7	Very slight flash and oil throw; glass broken; casing just noticeably warm
28	30	—	27	Glow in tube and fairly light splash
29	38	46	48	Glow in tube and fairly light splash
7/8	19	—	4·5	Fuse in series with a 2000 ohms resistance. Cleared very easily. Slight glow and ripple on oil surface

None of the fuses failed to clear the short circuit. At low voltages the usual slight momentary glow and an almost imperceptible ripple on the oil surface were experienced. In nearly all the tests at the higher voltages some oil throwing occurred, and was dependent on the point of the voltage wave at which the short circuit was imposed. But even at the highest voltages the disturbance experienced was insufficient to give rise to damage to a transformer tank lid under actual working conditions. In general, the fuse glass was broken, but owing to the fuse construction fragments of glass did not escape from the casing.

Tests were also made to check the thermal capacity of a fuse connected in the primary of a potential transformer switched in on over-volts, when it was found that the fuse continued to pass the current for a time which, in practice, should be sufficient to permit the cause of the irregularity to be removed before the fuse blew.

The effect of a prolonged current slightly less than the fusing current was to raise the oil temperature and thereby to give rise to the possibility of the Bakelite being impaired and its dielectric strength lowered, although the risk of these conditions arising is said to be very slight. During the test the fuse carried a current slightly lower than the minimum fusing current for nearly two hours with the oil in circulation to ensure a steady temperature rise. Small test pieces of Bakelite placed between the lamp and Bakelite enclosure were compared with similar untested pieces of the same material, and the test samples appeared to be unchanged in quality. After the Bakelite had been allowed to cool, it was tested at a pressure of 76 kV with satisfactory results.

From these tests it was concluded that from the point of view of breaking the circuit, the fuse is perfectly satisfactory, and that it has a suitable fusing current. It is unaffected by hot oil and will withstand prolonged vibration at high voltages. It will also stand the passage of a current approaching the minimum fusing current for considerable periods without deterioration.

(To be continued.)

Literature.

Industrial Furnaces. Vol. I. Third edition. By W. TRINKS. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd. Price 37s. 6d. net.

PREVIOUSLY, the methods employed in the designing and operating of industrial furnaces were very largely empirical, having been gradually evolved and developed from the experience of past generations. It is therefore somewhat remarkable that the construction of furnaces has in general proved to be based on fairly sound principles, but their further advance in practice must necessitate the carrying out of original constructive experiments, and for success in this direction a knowledge and application of the underlying and fundamental principles is essential. Few men have had the long and varied practical experience of industrial furnaces which the author of this volume has enjoyed, and the distinctive value of the present edition is that in it he has given us the full benefit of his studies. Its value is enhanced by the inclusion of numerous diagrams and illustrations. For this edition the text has been very largely rewritten, prominence being given to recent developments in furnace building technique, the problems of furnace design, burner design, the source of heat energy, and the selection of the best type of furnace for a given purpose. The second volume will be devoted to a study of heating and handling methods.

In an introductory chapter the author discusses the elements of furnace construction in a practical manner. Reviewing the general aspects of the heating capacity of furnaces, the heating capacities of electric, intermittent, muffle, and annealing furnaces are surveyed, and the factors which affect heating capacity in general are discussed. Two sections are devoted to a study of the fuel economy and thermal efficiency of furnaces and the means which have been employed to economise heat and to reduce the heat consumption per unit of material heated. Reference is made to the two distinct lines of development which have been followed in recently constructed continuous furnaces for heating thick sections, the first of which is based on the idea of increasing the heat transfer at the cold end, thereby allowing the longest possible time for the temperature difference to equalise. The other line of development has resulted in the many applications of the double-fired and triple-fired furnaces. A valuable section discusses many of the difficulties which are inherent in recuperators, but which are avoided by regenerators, and a brief account is given of waste heat boilers in connection with heating furnaces.

One of the most interesting parts of the book is the section which deals with the maintenance of furnaces, and gives the properties of the materials employed in furnace construction and the strength of different furnace elements. Here an attempt is made to indicate how furnaces may be designed, constructed, and operated in order to be free from expensive maintenance costs. In view of the importance of a clear understanding of the movement of gases in furnaces, the final chapter is devoted to a concise account of this aspect of industrial furnaces, a detailed study being made of the size and location of ports, flues, and stacks. Highly serviceable appendices which deal with graphical methods for finding the heat flow in plates, the calculation of heat transfer coefficients, and recuperator and regenerator calculations are given.

SHORT NOTICES.

Handbook for Electric Welders. London: Murex Welding Processes, Ltd. Edited by J. H. Paterson. Price 2s. 6d.—Intended originally as a guide to those who wish to perfect their knowledge of electric welding, the seventh edition of this useful book differs from its predecessors in that a good deal of the elementary material relating to methods of welding has been omitted. Such instruction is now easily obtained at most technical institutes, and in the training departments of firms specialising in welding, and its inclusion in a book of this nature has now been deemed to be unnecessary. In its present form the book deals with the subject from a broad aspect without any attempt to fill in minor details. It is a guide to those who wish to perfect their knowledge of the applications of electric welding, but it is not intended to serve as a text-book on physics or metallurgy. For the benefit of those who wish to increase their knowledge of these subjects, however, a short bibliography is given at the end of most of the chapters to help the reader in the selection of other books.

The Weekly Weather Report. London: His Majesty's Stationery Office. Price 7s. 6d. (postage extra).—This report relates to the period from February 26th, 1933, to March 3rd, 1934, and contains data relating to temperature, rainfall, and sunshine for each week in the twelve months. The whole sequence of data from each single station is arranged upon a single page and the number of observing stations concerned is fifty-seven, scattered over the length and breadth of the British Isles. It is interesting to observe from the tables that the deficiency of rainfall during the year varied very considerably as between districts. The Channel Islands suffered a deficiency of only 17 per cent., whereas N.W. England and North Wales for the period were short of rain by 37 per cent. It is not surprising, in view of the lack of rain, to find that the mean temperature in all districts was substantially above normal. Copies of the report are obtainable through any bookseller or directly from H.M. Stationery Office at London, Edinburgh, Manchester, Cardiff, or Belfast.

Central Heating and Hot Water Supply. By J. W. Cowan. London: Percival Marshall and Co., Ltd. 1934. Price 3s. 6d.—This little book is primarily written for the practical man who desires to work out the arithmetic of hot water supply from a central source. But in order to make him understand what he is doing, it opens with a section on the principles involved, and ends with a couple of chapters on appliances and similar matters. The treatment throughout is characterised by simplicity and clarity, and the little volume may be commended, particularly to young hot water engineers and to builders, artizans, and others whose duty it is to fix domestic hot water services.

Surveying for the Drawing Office. By L. C. Stanley. London: The Draughtsman Publishing Company, Ltd. Price 3s.—This brochure has been issued for the Association of Engineering and Shipbuilding Draughtsmen. We have perused it with much interest and have no hesitation in recommending it to anyone who wants to obtain a good grasp of the elements of surveying and surveying instruments. Whilst it does not pretend to compete with more advanced works, it contains quite enough to enable an intelligent man to carry out simple and moderately difficult surveys. The description of surveying instruments, and the comments upon them, are excellent.

Railway and Road Matters.

THE L.M.S. Railway Company has placed a contract with a Glasgow firm for the provision of a new caisson at Devonshire Dock, Barrow-in-Furness.

WE regret to announce the death on November 7th of Mr. Nils P. P. Sandberg, the third son of the late Mr. C. P. Sandberg. He was a member of the firm of Messrs. Sandberg, consulting engineers, and the inventors of the sorbitic treatment of rails and of the Sandberg steel sleeper.

ONE of the ablest administrators of Indian railways has passed away in the person of Sir Robert Highet, who died, at the age of seventy-five, on November 9th. For fifty years he was identified with the East Indian Railway, of which system he became the chief engineer in 1903, and the agent—a position corresponding to general manager—in 1912, and soon after the war came to England and became the chairman.

GOOD news reaches us from the Horwich Works of the London, Midland and Scottish Railway. They will be closed for Christmas Day and Boxing Day; reopen on Thursday, the 27th, and to compensate for the two days' holiday, will work on the Saturday. It is many years now since Horwich was open on a Saturday. In accordance with local custom, New Year's Day and the following day always have been a holiday; this year the works will be closed for New Year's Day only. Nearly every department of the works is busier than it has been for years. In the foundry a considerable number of men were taken on recently to cope with orders for new engine parts.

ON the morning of Thursday, November 8th, the 7.5 electrically operated train from West Worthing to London Bridge was standing in Haywards Heath station awaiting the arrival of the 7.19 from Brighton, so that both trains could be joined and run forward together. Through, apparently, an error of judgment on the part of the motorman of the train from Brighton, that train did not pull up in the rear of the Worthing train, and a collision resulted. There were some minor personal injuries, but these probably would not have happened were it not for the practice of many of the passengers from Brighton to jump out of their carriage, run forward, and enter the coaches of the Worthing train so as to get through the ticket barrier at London Bridge a few seconds earlier. The matter is so minor that we should not have mentioned it were it not for the fact that the line is equipped with automatic signalling. The signals at Haywards Heath are, however, worked from a signal-box.

FROM a communication that appeared in the Press on November 10th, it seems that the Ministry of Transport has acted, in the recent orders to the municipal authorities in London as to pedestrian crossings, contrary to the advice of the London and Home Counties Traffic Advisory Committee—see the note as to the purpose of that body in this column on October 5th. The Committee, according to the present communication, reported to Mr. Hore-Belisha on October 12th that it proposed to review the efficiency of the markings laid down in the light of experience, and also that it intended to review the scheme of pedestrian crossings in London as soon as the crossings have been given a reasonable trial. The letter in question proceeds to give a history of the question, and then says that Mr. Hore-Belisha remains of opinion that the present scheme of marking should receive a fair and adequate trial. The public is becoming accustomed to crossings so marked, and would be further familiarised with them if the experiment were carried out on the scale for which he has asked—10,000 crossings.

THE letter in *The Times* from Mr. R. Carpmael, of the Great Western Railway, as to steel sleepers, to which reference was made herein on September 7th, has now been followed by a communication in the same journal on November 9th from Herr R. Vogel, of the Society for Research on Permanent Way, Berlin. Herr Vogel says that in Germany, to-day, with improved design, steel sleepers compare with and are equal to wooden sleepers. As a result of recent technical experience and comparative tests, it has been proved that they can be ballasted as effectively as wooden sleepers, and that their resistance to lateral and longitudinal motion is at least 50 per cent. more efficient than that of timber, thereby overcoming "creep." Herr Vogel maintains that "creep" is largely dependent on the effective fastening of the rail. If sleepers could be absolutely fixed, there would still be "creep" if the fastenings permitted any movement of the rail. On the question of the damage to sleepers in derailments, he says that his own experience is that steel sleepers—even of light section—are seldom so damaged as to need removal from the track.

SOME ten or so years ago a subject to which we occasionally referred was the congestion caused on the Metropolitan Railway by the bottle-neck between Baker-street and Finchley-road, where there was only a double line, nearly wholly in tunnel. That line was authorised in 1864, to be constructed by an independent company, and it was opened as far as Swiss Cottage on April 13th, 1868. The works stopped there, but were resumed after powers had been given in 1873 to extend the line to Willesden. In 1877 the Metropolitan acquired the line, and it was opened to West Hampstead on June 30th, 1879, and to Willesden Green on November 24th of that year. Meanwhile, the facilities at Baker-street and eastwards thereof have been increased, and the line northwards of Finchley-road has four tracks, but the two intermediate between those points have remained unaltered except to have automatic signals. A solution of the problem appeared to lie in the provision of a new line from Willesden Green to Edgware-road, and powers for that were obtained in 1925, but nothing was done therein. The situation is now, however, changed by the creation of the London Passenger Transport Board, and the consequent community of interests. Its remedy is to make a junction with the Baker-street and Waterloo at Baker-street, and have a tube railway running to the east of the St. Johns Wood line, to West Hampstead. That not only will solve the problem of congestion, but will allow for the "Bakerloo" trains to run on to the Harrow and Uxbridge lines. Powers for this work are to be sought.

Notes and Memoranda.

AN investigation carried out by the Port of New York Authority indicates that the sodium vapour electric lamp can be used in clerical offices without injuriously affecting the eyesight of employees.

A PLANT for the production of non-poisonous coal gas is being set up at Hameln, in Germany. The process is one of converting the carbon monoxide content of the coal gas into carbonic acid and hydrogen by treatment with steam.

AFTER sixteen years of work, carried out in the face of great difficulties, the 5-mile Tanna railway tunnel in Japan has been completed. It effects a 30-mile cut-off on the Tokaido main line, and reduces the summit level from 1499ft. to 259ft.

THE world's largest welded bridge, at Stalinsk, across the river Abushka, was recently tested and opened for tramcars and traffic. The bridge at its widest span is 85 m. and the width 18 m. The bridge at Dresden, with a 26 m. span and a width of 11·5 m., was previously the largest welded bridge in the world.

IN a recent letter to *Nature*, Dr. R. Lessing reveals a hitherto unsuspected constituent of coal—fluorine. Dr. Lessing was investigating the cause of severe disintegration of porcelain tower fillings over which hot ammoniacal liquor circulated, and it was found that the attack was due to fluorine, which was shown to be present in appreciable quantities, probably in the form of ammonium fluoride. Upon examining a number of other coals, the presence was established in all of them in amounts not exceeding one part per million.

THE new South Deep vertical shaft of the New Consolidated Goldfields has reached a depth of 550ft. Sinking was started on July 1st this year, and it is expected that the shaft will reach its ultimate depth of 6300ft. by the end of 1936, says the *South African Mining and Engineering Journal*. This vertical shaft will be the deepest in the world, and the undertaking will involve several new features and, when completed, easy access from the shaft to the claims, which correspond to a reef horizon of approximately 8500ft. below the surface, will be attained by one stage of incline shafts.

A PROCESS for the manufacture of light concrete patented in Germany consists in incorporating into the concrete structure small preformed clay bodies of highly porous character. It is claimed that in this way a concrete is produced which is a good insulator against the flow of heat and sound, has a specific weight of less than 1·5, and can be handled by any present construction machinery including the concrete pump. Its compressive strength is said to be very much greater than that of other types of light concrete and to amount, after mixing, to 100 kilos. to 250 kilos. per square centimetre.

A NEW nitriding cast iron composition, containing no aluminium, has recently been patented in the United States, says the *Iron and Coal Trades Review*. A French metallurgist has assigned to the Nitra Cast Iron Corporation of Delaware a composition of the following approximate range: Carbon (total), 2 to 4 per cent.; manganese, up to 1 per cent.; silicon, 1 to 4 per cent.; chromium, 1·5 to 3·5 per cent. If other elements are included, the tungsten content is not to exceed 2 per cent., and the titanium, vanadium, and molybdenum not over 1 per cent. After nitriding cast iron of the above general composition, the Vickers-Brinell hardness has been raised in one case from 490 before nitriding to 710 after, and in another from 424 before to 780 after.

SEVERAL omnibus and lorry manufacturers have standardised stellited exhaust valve seats in their engines. Tests have shown no regrinding or refinishing of the valves to be necessary after runs of 100,000 to 150,000 miles, and the seating surfaces remained in good condition, says an extract in the *Automobile Engineer*. The valve seats are of the threaded removable type with the layer of abrasion-resistant alloy applied by the oxy-acetylene process. After welding, the valve seat is rough ground, then threaded on the outside and provided with serrations on the inside. It is then locked in place in the counterbore by set-screws or dowels, and a high-speed grinding wheel, held concentric with the valve stem, is used to finish the hard-faced seating surface.

THE Official Returns rendered to the Electricity Commissioners show that 1434 million units of electricity were generated by authorised undertakers in Great Britain during the month of October, 1934, as compared with the revised figure of 1245 million units in the corresponding month of 1933, representing an increase of 189 million units, or 15·2 per cent. The number of working days in the month (*i.e.*, excluding Sundays) was 27 as against 26 last year. During the first ten months of 1934 up to the end of October, the total amount of electricity generated by authorised undertakers was 12,307 million units, as compared with the revised figure of 10,604 million units for the corresponding period of 1933, representing an increase of 1703 million units, or 16 per cent.

IN an article in the *Iron Age* describing the manufacture of Chrysler motor car bodies, particulars are given of the method of protecting workers from the fumes resulting from spray painting. There are some thirty-six spraying booths, each protected by what is called a "fresh air curtain." These curtains, consisting of controlled currents of cleaned, filtered, and tempered air, vary in thickness from 3in. to 6in. They are forced by fans through rows of vents around the domed ceilings of the booths, and flow downward to within a few inches of the floor, where they disintegrate into small currents. These small currents are pulled into the booths and up through openings in the centre of the ceilings by additional fans, picking up paint fumes and dust on the way. This process has made it possible to open up spray booths instead of having them closed off, the air curtains forming the partitions between them. Production of these air curtains requires 20,000 cubic feet of filtered air per minute per booth at a temperature of 80 deg. Air travels from suction fans to the point of use through large metal conduits. Air curtains are also employed at the ends of drying ovens to seal in the heat. They are so effective that the temperature within 2ft. of the oven is 70 deg., whereas just inside the oven it is 300 deg.

Miscellanea.

DEEPENING of the St. Lawrence River channel in the vicinity of Cap de la Roche, which has been going on intermittently for the past thirty years, will probably be finished during this month.

A NEW 12in. rolling mill is being laid down at the works, at Rotherham, of the Park Gate Iron and Steel Company, Ltd., and it is expected that it will be ready for operation before the end of this year.

IT is reported that two thousand wireless stations are to be erected on collective and State farms in the U.S.S.R., thus enabling them to keep in touch with one another and with the Moscow headquarters.

IT was recently announced at a meeting of the Tees Conservancy Commissioners that a new jetty for the direct loading of petrol into ships had been finished and that service pipes from the new coal hydrogenation plant at Billingham are being fixed.

IT has been officially announced that a large works covering 20 acres and costing some forty million francs is to be constructed in France for the production of petrol by means of a "special treatment of coal." Preparations for the erection of two experimental works in the Pas-de-Calais have begun.

A LEAD Sheet and Pipe Development Council to extend the use of lead in Great Britain has been formed. Its object is to provide technical and other information to architects, contractors, and to the general public, and establish close co-operation with British water undertakings and plumbing firms.

A JOINT committee of Caernarvonshire and Anglesey County Councils has reopened negotiations with the Ministry of Transport for the construction of a new suspension bridge across the Menai Straits to supersede the bridge erected over 100 years ago by Telford, which is now regarded as becoming unsafe and having served its purpose.

THE Canadian Pacific liner "Empress of Britain" has just completed her sixteenth trip between Southampton and Quebec in as many weeks. This achievement has been rendered possible by curtailing the periods in port both at Southampton and Quebec to a minimum, and, with but one or two exceptions, the turn-round has been completed in under forty-five hours.

GOOD progress has been made on the San Francisco–Oakland Bridge, which has been under construction for 1¼ years, says *Engineering News-Record*. It is expected that the stringing of the wire in the suspension cables on the twin west crossing spans will begin next February. Three of the four west bay towers are complete, and the total amount expended on the work to date is about 19 million dollars.

THE Dixence hydro-electric power station in Switzerland is nearing completion. It will be one of the largest plants of its kind in the world and comprises five groups, each of one alternator driven by two Pelton wheels. Each group is capable of producing nominally 21,250 H.P. The power will be distributed all over French-speaking Switzerland, an area of about 4350 square miles, and part of it will be exported to the French Departments of the Ain and Doubs.

FOR the construction of the south pier of the San Francisco Golden Gate Bridge the engineers constructed a caisson, but after floating it to the site and placing it inside a fender ring decided to dispense with it. They are, instead, completing the fender ring and intend to use that as a cofferdam, which can be sealed and pumped out, thus permitting the pier to be built in the dry. The caisson measured 90ft. by 180ft. and was 75ft. high, with a weight of over 1000 tons.

IN reply to a question in Parliament as to whether any safety switch had yet been invented for automatically cutting out the electric circuits in aeroplane engines in the event of violent impact, thus minimising the danger of fire, and whether any such device had yet proved satisfactory, Sir P. Sassoon said that three designs of such switches had been investigated and tested. Each fulfilled the functions for which it was designed and approval had been given for their use in civil aircraft.

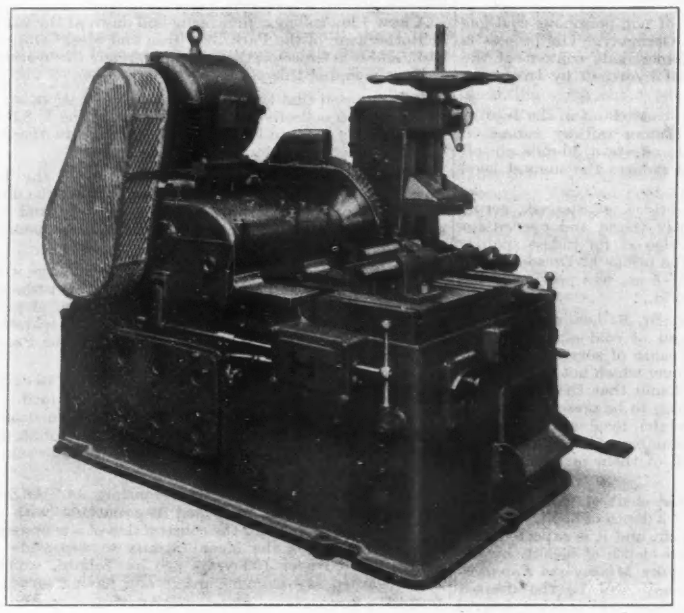
ACCORDING to Mr. Chas. U. Peat, M.P. for Darlington, "an important group of business men prominent in the English steel industry" is behind a project for the establishment of a new works in the North of England—probably at Darlington—for the production of cold-rolled steel. Search is now being made for a suitable site and it is understood that £500,000 is available for the erection of the plant, which is intended to employ sheet steel in the manufacture of motor car bodies, window frames, doors and partitions, and steel office furniture.

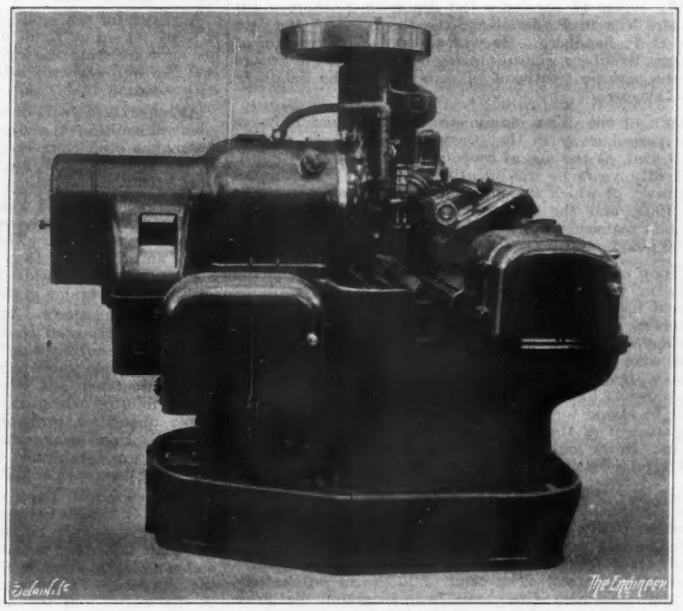
A NOTE in the *Electrical Review* says that the Western Union Telegraph Company's cable ship "Lord Kelvin" has been experimenting with a special plough designed to bury submarine cables in the ocean bed. Tests in Bigbury Bay, off the Devon coast, have already shown that it is possible to bury a cable in the sea bed at depths of 200ft. Attempts made at a depth of 3000ft. in the Atlantic Ocean are also claimed to have been successful. Altogether 20 miles of cable are reported to have been laid 100 miles south-west of Ireland. So successfully was the cable buried that only once in twenty attempts were specially prepared grapnels able to pick up the cable again.

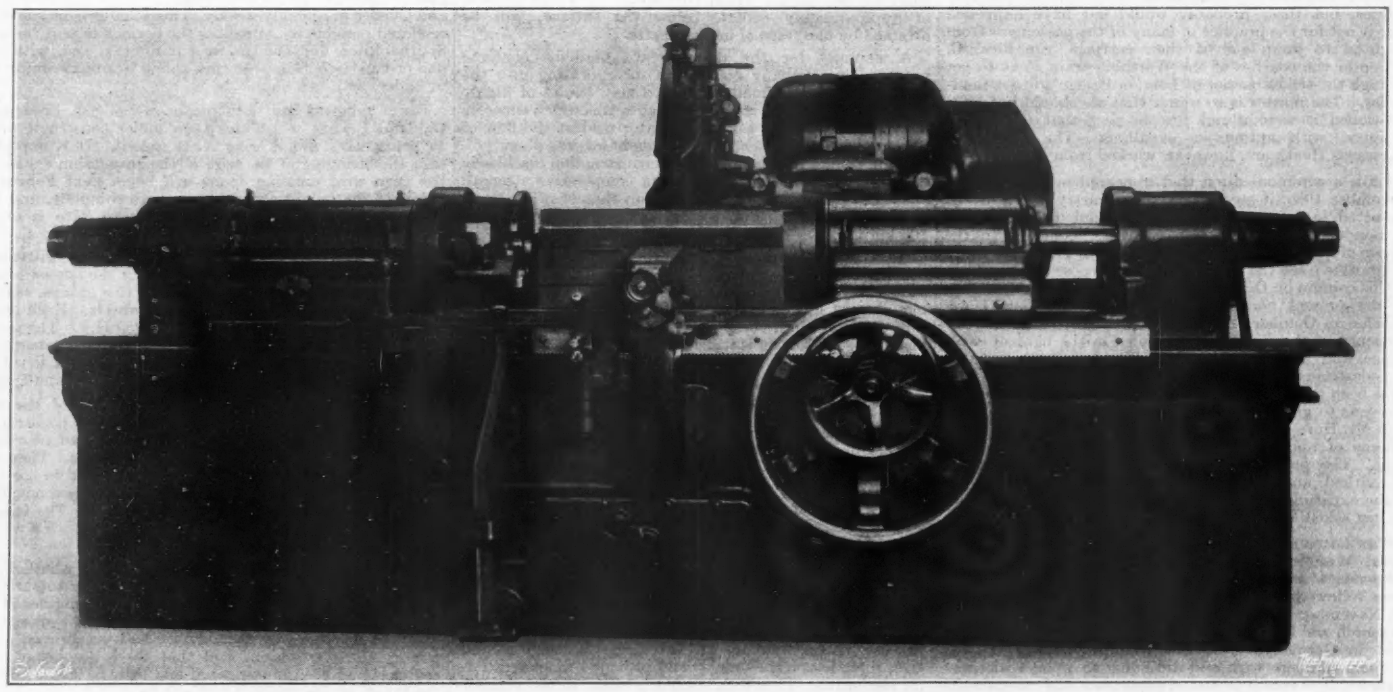
TELEPHONE subscribers in Stockholm have been provided with a new facility, by which they are informed accurately and automatically what the time is to the nearest ten seconds. The installation has been devised by the L. M. Ericsson Telephone Company, and it comprises an electrically controlled clock and a gramophone with records actuated by light cells. When the automatic telephone has put the subscriber in connection with the clock lights shine on three records at the places of the hour, the minute, and the tenth second. The gramophone loudspeaker then reproduces the numbers in their right order. Thus, if the time is 14 minutes and 23 seconds past 6 in the evening, the voice will say 18.14.20. There is no special charge for this service, though the call is counted as one of the number allowed for by the telephone subscription.

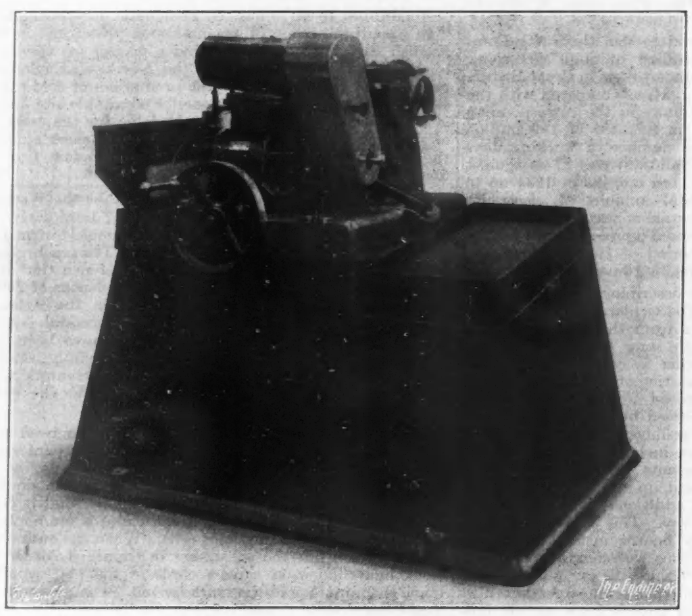
EXHIBITS AT THE MACHINE TOOL AND ENGINEERING EXHIBITION

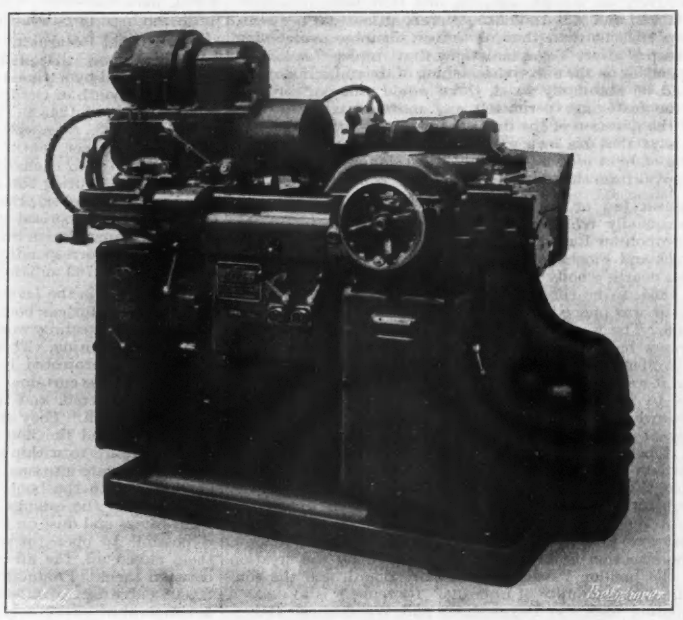
(*For description see page 478.*)











TOP: FIG. 14—COLD-SAWING MACHINE—RUSSELL

TOP: FIG. 15—GEAR AND SPLINE HOBBER—PFAUTER

CENTRE: FIG. 16—CRANKPIN GRINDING MACHINE—NORTON

BELOW: FIG. 17—CENTRELESS GRINDER—SCRIVENER

BELOW: FIG. 18—AUTOMATIC INTERNAL GRINDER—HEALD

The Engineer

NOVEMBER 16, 1934.

VOL. CLVIII. No. 4114

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FLYING SPEEDS IN CIVIL AVIATION.

ONE of the most eagerly canvassed public questions of the day, in this and in other countries, is the speed at which National civil aviation transport services should be run. It is a question which would be expected to be essentially technical, but at the moment the issue is coupled—if not submerged—by political aspects. The alternatives can be thus stated: Should the speed of air transport be so chosen that the service will pay for itself, or should the taxpayer be ready to help with whatever subsidy is appropriate to a substantially higher speed? Each country appears to have its own way of answering this question, and each, as time goes on, appears to be disposed to raise the operating speeds, almost as though there were a natural national rivalry as to which could go fastest even when the routes operated have quite divergent characteristics. What to an engineer would have seemed a question appropriate to settlement on quite other lines comes to be viewed almost as if it were as much an international sporting event as the Schneider Trophy Contest!

The policy officially adopted in this country has been to encourage civil air transport to "fly by itself." Imperial Airways receives, it is true, an annual subsidy from State funds, but on a sliding scale and with the object and intention that it shall one day vanish. The purpose is clear, namely, that of helping an infant industry to its wings, and then of letting it fly alone. Although Imperial Airways does not publish detailed accounts of its operations on the various routes served, it is generally believed that the revenue from the existing London to Paris service would suffice to pay the costs without any subsidy at all. This, which once seemed a remote objective, is already in sight. The success of Imperial Airways has been obtained largely by its attention to technical issues; the meticulous care which has reduced the flying risks, and so attracted traffic; the improved equipment which has led to an increase in comfort and a vast reduction in noise, coupled with ample speed to beat the alternative surface modes of transport. A purely commercial attitude is, however, by no means the only one that could have been assumed in regard to this particular air route, or any other. Other motives which might have entered, but in the case of this country did not, were the purely military conveniences in respect of the building up of reserves of pilots and aircraft—especially in regard to speed and general convertibility to warlike ends. A critic of our present speed schedules might, however, urge that although they may suit a special service like that from London to Paris, where, in any event, much of the time of the journey is not spent in the air at all, there is good reason for putting faster aircraft on the Africa, India and Australia services—claiming that the saving in time would be considerable, that many more passengers would be attracted, and that a large revenue from mails should be obtainable. The alleged advantages of an increase in speed, which, for the sake of argument, may be put at 100 to 200 miles per hour, are now being actively canvassed. Such an enhancement in speed would, however, involve a still larger increase in engine power, even with the most efficient aerodynamic cleaning up of the design, and on some of our routes, the African particularly, the price of fuel is exceedingly high; if fuel costs are to be put still higher, and if the structure weight has to be increased to carry the larger engines, and the necessary sound-proofing material to make conditions tolerable for the passengers, the need for a balancing subsidy—and the tilt of the balance is likely to be steep—will be imperative. This must fall on the taxpayers either directly or indirectly. It is suggested, by a recent estimate in our contemporary *The Times*, that to put British air transport on the same easy financial footing as the American would cost at least 6½ million pounds a year, equivalent to three halfpence on the income tax. Is it possible that the income tax payer will regard this way of spending part of his income as better than any way he could devise for himself? And even this expenditure is not the whole, since it covers only the aircraft costs and leaves out a large part of the ground organisation. Passengers by air have usually so far preferred to take long journeys by easy stages, and to spend their nights on the ground. This, of course, greatly reduces the average speed of travel, and may be but a transitory phase appropriate to the infancy of the art. When, however, night flying becomes usual, which, for fast mail carrying, it is impelled to become, passengers will be able to make more rapid journeys, though at some enhanced travel risk, at least until such time as the various world air routes are sufficiently "lit" either by visual radiation or by other forms of longer wave length. Radio guidance to aerodromes is now frequently provided, and it has almost reached the stage of permitting entirely "blind" landings to be made when the atmospheric conditions preclude normal ones. Actual landings in really thick fog, though they have been made, are not yet safe for a passenger service. These ground services are ready in some instances for immediate extended application; others need development before they can be efficiently applied.

It was a highly creditable achievement of the de Havilland firm to produce within a few months such an aeroplane as the "Comet," which, without any development trials whatever, was able to fly almost continuously the 11,000 miles to Australia and to make the flight in under three days. Our ability to construct aircraft for whatever flying schedule may be needed to fulfil the requirements of civil air transport is not in doubt. The American constructors have profited much in recent years from the vastly costly testing plant provided in the days of its prosperity by the American Government. Civil air transport in America has benefited also by other factors, which barely exist in Europe, such as the ability to cross state frontiers without formality, long routes serving highly progressive communities, and a vast expenditure on air route equipment and aerodromes. These facilities, with the financial encouragement of a very liberal mail subsidy, have had the effect of producing a large and enterprising aircraft industry quite apart from the stimulus of the provision of military types. These factors, combined with the high speeds appropriate to long journeys carrying mails, have encouraged the introduction of many mechanical inventions which are making their way around the world, much as the British Handley Page safety slot invention did a few years earlier. These inventions include the retractable undercarriage—adopted some millions of years ago by nearly all birds—the variable, or adjustable, pitch airscrew, and the use of special flaps or slots for slow landing at normal attitudes. With these devices speeds can rise provided the public is willing to pay the price. Indeed, no purely physical limit to the speed of flying is encountered until the velocity of sound is approached, when the resistance curve rises with a rush so steep that it is very unlikely that speeds above 600 miles an hour will be seen by anyone now living. In fact, they are unlikely to be attained at all unless and until some form of prime mover at least ten times as powerful for its weight as anything at present known is invented. Whether that is likely is a speculative proposition, and though nothing of the sort is in sight, one would be rash to say that it will never be discovered. After all, the speed of travel remained almost constant from the reign of Julius Cæsar to that of Queen Victoria, and it is only within the last hundred years that the curve has risen steeply upwards.

The question of the speed of operation of commercial aircraft was keenly debated at a recent meeting of the Royal Aeronautical Society following a somewhat optimistic analysis of the technical problems involved by the well-known French aeronautical engineer, M. Breguet. The lecturer anticipated that in the very near future the commercial aeroplane would be designed to a wing loading of 20 lb. to 30 lb. per square foot, possess means of increasing the lift considerably, have air brakes and ground brakes, and employ sufficiently supercharged engines to be capable of a cruising speed of 200 miles an hour at 12,000ft. altitude. This speed, it was suggested, would suit the Indian, African, and South American routes. Now, this is to claim for these routes a speed equal to, or even better than, that customary on the routes in the United States. But in the latter country air transport has, in order to be attractive, to compete with fast railway services, whereas on the other routes cited the competing surface craft are partly maritime, and hence, on this ground alone, there would be little need for proceeding so fast. But it is unwise to dogmatise since the distances apart of the best fare-collecting termini must be an important factor, and the question also enters of the possibility of reducing the number of aeroplanes necessary to serve a given route if the distance covered in twenty-four hours can be decidedly increased. These are questions which can only be answered by those who are actively engaged in running such services, and it is clear from Sir Eric Geddes' recent speech at the general meeting of Imperial Airways that they are now actively engaging the attention of that board.

Build British Bridges.

A POSTER to be seen on many hoardings depicts a workman, walking along with jaunty and elastic step, carrying, balanced upon his head, an enormous girder. On one of these posters a passer-by, in Imperialistic and alliterative vein, has chalked upon the dark background of the girder the words "Build British Bridges." In the course of a recent interview, Mr. Ralph Freeman, whose association with big bridges began some thirty years ago, when the Victoria Falls Bridge was built across the Zambesi River, and whose latest triumph, the Sydney Harbour Bridge, was completed two years ago, gives the same advice to build more bridges in Great Britain and the British Empire. He points out that, prior to the building of the Quebec and Sydney bridges, no really long-span bridges had been constructed in the whole of the British Empire since 1890, when the Forth Bridge was completed, and refers to the need of long-span bridges across the estuaries around our coasts to further road development.

There can be no doubt that the three bridges to which Mr. Freeman refers are correctly described as long-span bridges, because they closely approach what has been considered the limiting span across which a steel structure can be designed to carry even its own weight, although this limit has been increased with the use of high-tensile steel. Since 1890 several bridges have been built of fairly long span, such as the new Wearmouth Bridge at Sunderland, the Tyne Bridge at Newcastle, the Victoria Falls Bridge over the Zambesi River, and the St. John River Bridge in Canada. All these are arched bridges of from 375ft. up to 565ft. span. The Widnes and Runcorn Transporter Bridge across the river Mersey has a span of 1000ft. These eight bridges have at least one point in common. They are founded upon rock, and the lack of suitable foundations is probably a predominant reason why more long-span bridges have not been built in this country, and why communications across the lower reaches of the Thames, for example, have been obtained by tunnelling rather

than bridging. But there is another important consideration: that of cost. Although traffic through the Thames tunnels has considerably increased, up to the point of congestion in the case of the Blackwall Tunnel, these means of communication have provided sufficient accommodation, during the quarter of a century they have been in service, for the remarkably low initial cost of about £400 per lineal yard for the portions of the tunnels under the river, whereas the cost of the Sydney Harbour Bridge, including the approach spans, was certainly not less than £3500 per lineal yard. A long-span bridge must, of necessity, be built of considerable width to obtain stability, and is therefore suitable for communications involving a large volume of traffic, or combinations of traffic, such as that of highways and railways. The Rotherhithe Tunnel accommodates a 16 ft. roadway and two footpaths, each 4ft. 8½in. in width, whereas the Sydney Harbour Bridge provides a 57ft. roadway, two footpaths, each 10ft. in width, and four lines of railway. To tunnel under a river, such as the Thames, it is only necessary to descend some 66ft. below shore level, whereas the approaches to a long-span bridge, designed to avoid interference with navigation, would have to rise two or three times that amount, with a corresponding increase in the length of the approaches. These are doubtless some of the reasons why more long-span bridges have not been built. But Mr. Freeman considers that more highway bridges would be constructed if it were not for the extraordinarily heavy loading stipulated by the authorities in order to provide for exceptional loads, which the structures are only required to carry at very rare intervals, if at all. We have referred to the unavoidable increase in the vertical and lateral dimensions of the superstructure of long-span bridges. For this reason the deck space is naturally proportioned on generous lines, and congestion is never likely to occur. Nevertheless, the minimum standard loading recommended for all highway bridges constructed in Great Britain is equivalent on a long-span bridge to a uniformly distributed load of about 170 lb. per super foot, excluding impact allowance, over the whole of the carriageway. The St. John River Bridge and the Sydney Harbour Bridge were designed for live loads of less than half this amount, but even so, 26 per cent. of the weight of steel in the Sydney Harbour Bridge is on account of vertical live load and impact allowance.

It is far from our intention to discourage the legitimate development of road transport, but there can be little doubt that the carriage of exceptionally heavy loads rightly belongs to the railway companies and canal companies. The railway companies have laid down tracks, designed to withstand heavy traffic, and provided special rolling stock to accommodate heavy or bulky loads. Even if the dimensions of these exceed the loading gauge, special arrangements can generally be made to effect the transport at times when adjoining lines are not being used. The highways in this country have been brought to a wonderful standard of excellence and economical maintenance, but this standard can only prevail if the roads are reserved for normal traffic. If this criterion were observed there would be no need to design highway bridges for abnormal traffic, and certainly not for a congestion of abnormal traffic which is never likely to occur.

University Degrees in Engineering.

No. III.

(Continued from page 453, November 9th.)

Leeds University.—The degrees open to engineers at the University of Leeds are B.Sc., M.Sc., Ph.D. and D.Sc. Graduates holding any one of these degrees may also proceed to the degree of M.Ed.—Master of Education. The academic year is divided into three terms and extends from the beginning of October to the beginning of July.

For both the ordinary and the honours B.Sc. degree the courses provided extend over three years. During the first year all students study and take an examination in mathematics, physics, chemistry and general engineering. During the second year there is again no distinction between ordinary and honours students or between civil, mechanical or electrical engineers, all classes continuing their studies of mathematics and general engineering and passing a further examination in these subjects at the end of their second year. Specialisation appears only in the third year, the curricula for which are different for civil, mechanical and electrical engineers and more extensive for honours students than for those aiming at an "ordinary" degree. Applied economics is included in the curricula and final examination of all categories. Honours students in each of the three branches take, and present themselves for examination in, one more subject than ordinary degree students, and are required to pass on a higher standard. The honours degree is awarded in three classes. If an honours candidate fails to reach the standard required for the third class he may be awarded the "ordinary" degree. He is not allowed to present himself twice for an honours examination in the same branch but he is allowed to defer presenting himself until the end of his fifth year. In the final examinations for both the ordinary and honours degrees a paper is set containing passages in French and German for translation into English—with the aid of dictionaries—the subjects of the passages being related to the candidate's degree course. This paper is not compulsory for engineering students but candidates who take it receive marks for correct rendering of the passages and for the command of English which they show. The composition fee for the B.Sc. degree course is £46 for each of the first three sessions and £38 for a fourth session.

The M.Sc. degree may be conferred upon holders of the B.Sc. degree with honours of one year's standing or of the ordinary B.Sc. degree of two years' standing. The qualification for the degree consists of the prosecution of approved research work and the submission of a thesis thereon together, if required, with an examination in the subject of the thesis. A fee of £5 is payable on submission of the thesis and one of £6 on graduation.

The Ph.D. degree is awarded to graduates of Leeds or of other approved universities who pursue for at least two years advanced study and research at Leeds under the direction of the Staff and who subsequently submit a satisfactory thesis on their work. The candidate may in exceptional cases be permitted to undertake a limited amount of outside work provided it does not interfere with his course of advanced study and research. The thesis is required to contain "original work worthy of publication." The fee for the degree is £10 plus £6 on graduation. Holders of the Ph.D. degree share with Masters of Arts the right to make application for the degree of Doctor of Letters—Litt.D.—six years after being accepted as candidates for the Ph.D. degree. The Litt.D. degree is conferred upon those whom the Senate deems "to have distinguished themselves by special research or learning." A candidate may submit a thesis in support of his application for the Litt.D. degree and may be required to pass an examination.

Bachelors of Science of at least six years' standing who have in the meantime taken the M.Sc. or Ph.D. degree may be awarded the degree of D.Sc. if they are deemed by the Senate to have distinguished themselves by their original contributions to science. A thesis, published or in a form suitable for publication, may be submitted in support of a candidate's application for the degree. Under certain conditions the thesis may be of joint authorship. The fee for the degree is £15 plus £6 on graduation.

To obtain the degree of Master of Education an engineering student is required to satisfy the examiners in the subjects of Education at his final examination and, subsequently to graduation as a Bachelor of Science, to pursue for a year a course of approved study or to have had a year's experience in the practical work of education combined with a course of advanced educational studies.

Sheffield University.—The University of Sheffield awards the degrees of B.Eng., M.Eng. and D.Eng.—Bachelor, Master and Doctor of Engineering—and the Ph.D. degree. In addition within the Faculty of Engineering it grants the degrees of B.Sc. Tech., M.Sc. Tech., and D.Sc. Tech.—Bachelor, Master and Doctor of Technical Science. These last-named degrees are conferred on students of fuel technology and glass technology and are therefore not engineering degrees in the strict sense. The academic year covers three terms extending from about the end of September to about the end of June.

The ordinary B.Eng. degree may be obtained by civil, mechanical, electrical or mining engineers or by students taking a combined mechanical and electrical course. Two alternative schemes of study are provided. Under the first, in the case of civil, mechanical or electrical students, candidates may complete their degree course by attending the University for three years, each year covering the three academic terms. Under the second—the combined University and works course—the degree is obtainable in four years, each year embracing the first two terms—from October to March—followed by a period extending from April to September during which the candidate is required to attend a works approved by the Faculty for practical instruction. Similar full-time and combined university and practical courses are provided for mining engineers. The examinations for the ordinary degree consist of the intermediate and the final. For all branches the intermediate examination covers mathematics, physics, chemistry and engineering drawing and design. In addition candidates must attend and reach a satisfactory standard in courses on the theory of machines and heat engines. Preparation for the final examination extends over at least two years that is over six terms under one scheme and four terms under the other. For the final examination candidates are required to take five subjects some of which are general and others special to their selected branch of engineering. In addition all candidates except mining students are required to attend and make satisfactory progress in courses on the testing of materials, industrial economics and iron and steel metallurgy. Mining students are required to have had eighteen months' approved practical experience and to pass a practical examination at a mine. The degree of B.Eng. is also awarded with first or second-class honours. To obtain an honours degree a candidate is required to study and pass in a special course of mathematics and in his final examination to take and pass additional special papers of a higher standard in two of the subjects of his degree course. In addition he is required during his final year to study and report upon some problem of engineering science or to submit an original design appropriate to his branch of study. The conditions for the honours degree in mining engineering are suitably modified. The fees for the full-time—or three-year—degree course are £41 10s. per annum and for the four-year or combined university and works course £31 5s. per year of two terms.

The M.Eng. degree is open to holders of the B.Eng. degree following at least one year of post-graduate research work at the University and the presentation of a thesis. Alternatively it may be obtained by a graduate of at least three years' standing who during three years subsequently to his graduation has pursued the science or practice of engineering and who presents a thesis approved by the Faculty of Engineering. The fee payable on submission of the thesis is £5 with a like fee on graduation.

The Ph.D. degree is awarded to honours graduates after at least two years of advanced study or research at the University or to holders of the "ordinary" degree after three years of such work. The thesis is required to contain "original work worthy of publication." Candidates are required to pass an oral examination on the subject of their theses and a further written examination if it is deemed necessary. The fee is £7 10s. plus £10 on graduation.

The degree of Doctor of Engineering may be conferred upon a graduate who has published in recognised journals or transactions particulars of research work recognised by the Faculty of Engineering as of sufficient excellence to qualify him for the degree. Candidates must be of at least five years' standing as Bachelors of Engineering. The fee payable on submission of the work on which the application for the degree is based is £10. A like amount is payable on graduation.

Reading University.—The University of Reading does not confer any degrees in engineering.

Durham University.—The University of Durham consists of a group of colleges at Durham, Newcastle-on-Tyne, Sunderland, and elsewhere. At Armstrong College, Newcastle, courses are provided for students of civil, mechanical, electrical and marine engineering, naval architecture, mining and metallurgy. The degrees awarded are B.Sc., M.Sc., Ph.D., and D.Sc.

The academic year comprises three terms and extends from about the first week in October to the end of June. For the "ordinary" or pass degree the course covers three years at the end of each of which an examination has to be taken. During the first year the student of engineering takes pure and applied mathematics, physics, chemistry, applied mechanics and drawing. A candidate may pass in four of these subjects at the end of the first session and in the remaining two just before the beginning of the second session. The subjects of study during the second and third years are mathematics and courses in engineering appropriate to the branch selected by the candidate. The second and final examinations cover these studies except that in mathematics the candidate is only required to "present evidence of satisfactory attendance at a prescribed course of study." In each of these examinations the subjects are divided into two groups. If a candidate fails to satisfy the examiner in any subject of the first group he is deemed to have failed in the entire group. If he fails in any subject in the second group he is given credit for those in this group which he passes and may present himself at a later date for re-examination in the subject in which he has failed. The degree may be taken in two instead of three years by a candidate who has completed at least two years' practical training, who has attended courses of instruction at an approved technical school or college after commencing his practical training and who passes the first examination for the degree—or the equivalent of that examination

—before beginning his degree course at the University.

The course for the B.Sc. degree with honours covers the curriculum and the examinations for the ordinary or pass degree together with one year's advanced study and a fourth or "final honours" examination. Advanced mathematics is included in the subjects of this examination. Honours candidates are required to undertake some approved research or to prepare a design or plan and to submit a thesis upon their work under this head. In addition they are required to demonstrate their ability to read and translate technical or scientific writings in at least one foreign language, either French, German, Spanish or Italian. Honours are awarded in three classes. No candidate is permitted to submit himself twice for examination for an honours degree. As in the case of the pass degree the honours degree may be taken after a two years' course at the University by a candidate who has completed at least two years' practical training. In this case he is required before entering on the degree course to pass the second examination for the pass degree—or the equivalent of that examination. The composition fee for the degree course is £40 per year.

The M.Sc. degree is open to Bachelors of Science of at least two years' standing who submit evidence of advanced knowledge in some division of science. Graduates of other universities may receive the degree following two years of advanced study or research at the University. The fee payable by a candidate is £5 plus £6 on graduation. The M.Sc. degree may be awarded honorarily.

The Ph.D. degree may be awarded to post-graduate research students who pursue for not less than two years a course of research under the supervision of the University and who submit a satisfactory thesis on their work. Unless specially dispensed by the examiners a candidate has to pass a written—and, if required, an oral—examination on the subject of his thesis. A candidate may while carrying out his research undertake paid duties in the University occupying a time not exceeding three hours a week. Applications from candidates who have undertaken duties other than university teaching are considered on their merits. On presentation of the thesis a fee of ten guineas is payable and on admission to the degree one of £5.

The degree of D.Sc. is open to Masters of Science or Doctors of Philosophy of Durham University four years after graduating in these degrees. The degree is awarded primarily in consideration of independent original work which has been published. The fee payable on application is ten guineas and on graduation £10. The degree may be awarded honorarily.

(To be continued.)

Obituary.

JAMES GORDON GRAY.

It is with great regret that we have to record that Dr. James Gordon Gray, Cargill Professor of Applied Physics at the University of Glasgow, died suddenly on November 6th. He was in his fifty-ninth year and was the second son of the late Professor Andrew Gray, at one time assistant, and later successor, to Lord Kelvin in the Chair of Natural Philosophy at Glasgow. James Gray's name will always be associated in scientific history with his work on gyrostats and the practical applications of gyroscopic theory. In that work he carried on the studies in the same subject made by his father who in turn inherited his interest in it from Lord Kelvin. Much of James Gray's gyroscopic work had however to be done under a veil of secrecy for it was conducted during the war and had direct application to naval and aerial equipment. It is known that he developed gyroscopic instruments to assist flying in clouds, or in other conditions under which the horizon is not visible, and other instruments to aid bomb sighting. He also devoted attention to the gyroscopic stabilisation of aircraft and of surface vessels. On several occasions he demonstrated sundry applications of the gyroscope before the Royal Society, the Royal Society of Arts, and other bodies, his most recent undertaking of this kind having been his series of "Thomas Gray" Lectures on gyroscopic pendulums which he delivered in April of this year before the Royal Society of Arts. James Gray was educated at Friars Grammar School, Bangor, at the University College of North Wales—where his father, before proceeding to Glasgow, held the post of Professor of Physics—and at Glasgow University. He served for some years as assistant and demonstrator to his father in the Department of Natural Philosophy at Glasgow, and in 1920 when the Chair of Applied Physics was established by the generous benefaction of Sir John T. Cargill, James Gray was appointed its first occupant. He had previously received a tempting offer of a similar professorship from the United States but declined it. He preferred to remain at Glasgow where so much of his life had been spent. Apart from his work on gyroscopes and their practical application he carried out many experiments on the magnetism of bodies at low temperatures. He was a member of the Institution of Electrical Engineers and of the Royal Society of Edinburgh. Of the father it may be said that he demanded from his students an almost religious reverence for scientific knowledge. The quiet, slow, kindly and nearly shy demeanour of the son carried with it to all who came under him a sense of the inevitable in science. Many of those who had the advantage of studying under both can pay tribute to the lasting benefit which their joint influence has exercised on their outlook and careers.

ALFRED WEEKS SZLUMPER.

By the death of Mr. Alfred Weeks Szlumper, C.B.E., M. Inst. C.E., formerly the chief engineer of the Southern Railway Company, which took place on Sunday, November 11th, at his home, Sheen Common-drive, Richmond, the civil and railway engineering world has lost an engineer of outstanding personality and ability. Although he retired from active work in June, 1927, Mr. Szlumper continued to the end to serve the Southern Railway Company in a consultative capacity, and his keen knowledge of such subjects as the Charing Cross Bridge scheme was greatly valued. At the time of his death he was about seventy-six years of age. Mr. Szlumper came of a well-known family of engineers, and was born in Milford, Pembrokeshire, on May 24th, 1858. He received his schooling at Aberystwyth Grammar School, and completed his education at the University of Wales, after which he served his pupilage with his brother, the late Sir James Weeks Szlumper, an engineer of eminence. During his pupilship he carried out railway work in Wales, and in 1880 was appointed an engineering assistant on the South-Eastern and Chatham Railway. That position he held for close upon two years, after which he was

ALFRED WEEKS SZLUMPER

appointed to a similar post on the Great Indian Peninsula Railway, which he held for about two years, during which time he was a resident engineer on a section of the company's work then being carried out. When he returned to England in 1884, he immediately took up a position with the London and South-Western Railway Company as an engineering assistant, and for twelve years he was in charge, as resident engineer, of many important widening schemes in both the London and the Woking and Basingstoke areas. Those works included the Nine Elms and Waterloo widening from four to six lines, except at the reconstructed Vauxhall Station, where the roads become seven. That particular work was described in a paper presented by Mr. Szlumper to the Institution of Civil Engineers in the 1891–92 session.

In 1897 he was appointed divisional engineer of the London division of the L. and S.W.R., and in 1914 he succeeded Mr. J. W. Jacomb-Hood as chief engineer of the company. That position he continued to hold with distinction when the Southern Railway was formed in 1924 until his retirement in 1927. His work included the rebuilding of bridges at Barnes, Richmond, and Kingston, the construction of the Bentley and Bordon railway, the fly-over at the Hampton Court junction, the gravitational shunting yard at Feltham, and much civil engineering work connected with the first electrification scheme which was, during 1913 and 1916, carried out by the London and South-Western Railway Company. The completion of the reconstruction and enlargement of Waterloo Station was also a work of which special mention should be made.

During the war period Mr. Szlumper rendered valuable services to both the War Office and the Admiralty, and in 1920 he was made C.B.E. He was a member of the Engineer and Railway Staff Corps, and was Lieut.-Colonel in the Corps at the time of his retirement in 1927.

Throughout his long career Mr. Szlumper was a valued member of the Institution of Civil Engineers, and he contributed to the Institution many useful papers. To him was awarded the Miller Prize, the Trevithick and Telford Premiums, and the Telford Medal. Throughout his life he was fond of foreign travel, and this gave him a breadth of vision which was marked both in his relations with his staff and friends. While he had a capacity for quick decision and unerring judgment, he always had a cheery word for everyone, whether high or low, and he lived a life of simplicity and happiness. His funeral was held on Wednesday last at Richmond, and with characteristic thoughtfulness for those of his profession, remembrance of the Institution of Civil Engineers' Benevolent Fund, was requested in place of flowers.

SIXTY YEARS AGO.

The decision of the Government in 1874 that unarmoured ships of war were to be armed with many small guns in place of a few large guns gave rise to much controversy among naval experts. In a leading article in our issue of November 13th of that year we discussed the subject. One school of thought, we noted, was headed by Mr. E. J. Reed and held that all our warships, whether armoured or not, should carry a few heavy guns capable of piercing armour. The other school, headed by Sir W. Palliser, contended that as unarmoured ships should never attempt to attack armoured craft it was desirable that their armament should consist of a large number of small guns. We remarked that the discussion was exhibiting a tendency to wander into side issues but that on its main lines it was of very great importance in so far as the safety of our commerce in time of war might depend almost wholly on the nature of the guns carried by our unarmoured cruisers. If it were taken as an axiom that an unarmoured ship was never to engage an armoured one then, we said, a large number of small powerful guns firing shells would be preferable to a few guns of heavy calibre because the chances of hitting an enemy increased in direct ratio to the number of guns just as the chances of hitting a partridge were greater with pellets than with a rifle bullet. Granted that fast unarmoured ships such as the "Raleigh" and the "Volage" were to be used solely to protect our commerce, that they would never be called upon to fight other than unarmoured enemy ships, and that their speed would always enable them to keep clear of ironclads then it was indisputably right to arm them with a multiplicity of small guns. It was however possible that such an unarmoured ship might find herself in such a position that she could not avoid trying conclusions with an ironclad. She might for instance be caught in a bay or be overtaken with her engines disabled or her fuel exhausted. In that event if she mounted nothing but 64-pounders no matter how numerous they might be she would fall a victim to the weakest ironclad afloat. To meet that possibility we suggested that our unarmoured ships in addition to a good supply of 64-pounders or some other good common shell gun should each carry one heavy long-range gun which would be competent to deal with ordinary armour, such for example as the 18-ton gun. We could trust our naval officers not to be tempted, by the possession of such a gun, to neglect their commerce-protection duties in favour of hunting about, knight-errant fashion, for small ironclads and thereby possibly catching a tartar. When to fight and when to refrain from fighting could be safely left to the discretion of our naval officers. But as fight they might have to, it would be as well that they should have one big gun to help them in their hour of need. . . . The interest of this article lies partly in the picture of naval warfare under the conditions of sixty years ago which it presents and partly in the revelation which it makes of the fact that the all-big-gun ship was, even in those days, being advocated by one school of naval thought.

BOOKS RECEIVED.

The Book of Speed. London: B. T. Batsford, Ltd., 15, North Audley-street, W.1. Price 5s. net.

Consular Directory and Imperial Trade Record, 1934. Lincoln: Elpeeko, Ltd., Melville-street. Price 5s. net.

Neon. By S. Gold. London: Crosby Lockwood and Son, Ltd., Stationers' Hall-court, E.C.4. Price 7s. 6d. net.

The Flow of Water. By G. Bransby Williams. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 10s. 6d. net.

The Ford Models V8, B. and A Cars. By V. W. Pagé. London: The Technical Press, Ltd., 5, Ave Maria-lane, E.C.4. Price 15s. net.

Memories of a Scientific Life. By Sir Ambrose Fleming, M.A., D.Sc. London: Marshall, Morgan and Scott, Ltd., 1, Paternoster-buildings, E.C.4. Price 5s. net.

A First Year of Engineering Drawing. Second edition. By A. C. Parkinson. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 5s. net.

British Commerce and Industry. Vol. I., *The Post-war Transition*, 1919–1934. London: Russell-square Press, Ltd., 48, Russell-square, W.C.1. Price 15s. net.

Collected Reports on British High-speed Aircraft for the 1933 Schneider Trophy Contest. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C.2. Price 10s. net.

Principles of Motor Fuel Preparation and Application. Vol. I. By A. W. Nash, M.Sc., and D. A. Howes, B.Sc. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 30s. net.

The Surface Condenser.

No. XIII.

(*Continued from page 452, November 9th.*)

The Water Side.

Velocity of Cooling Water Flow.—In an earlier article of this series it was noted that the rate of heat transmission from tube to water varies very approximately as the square root of the velocity. This matter was recently put on a more definite basis by a research carried out for the British Electrical and Allied Industries Research Association by Mr. A. Eagle and Mr. R. M. Ferguson, and the results were published in papers before the Institution of Mechanical Engineers and the Royal Society in 1930. One of the results of this research, as modified for practical use by Messrs. Guy and Winstanley, is given in the graph reproduced in Fig. 49, which

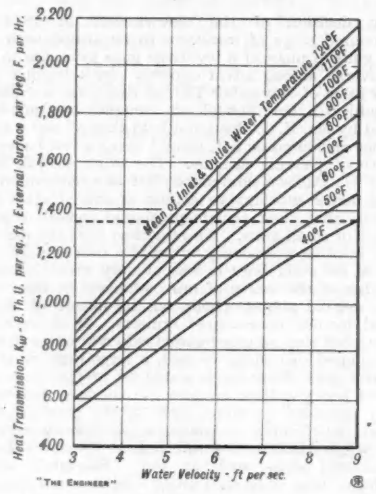


FIG. 49—VARIATION OF RATE OF HEAT TRANSMISSION WITH WATER VELOCITY

applies to tubes ¾in. in outside diameter, 18 I.W.G. thick, and to a rate of heat transmission per square foot of 8000 B.Th.U. per hour. The corrections to be applied for other rates of heat transmission are so small as to be negligible practically. Nor are the corrections for tubes of diameter larger or smaller than ¾in. external diameter of great significance. It will be observed from the graph that K_w, the rate of heat transmission per square foot of external surface per degree Fahrenheit per hour rises fairly rapidly with increase of the water velocity, and that its value is greater at any one velocity the higher the temperature. It should also be observed that the least velocity of flow shown on the graph is

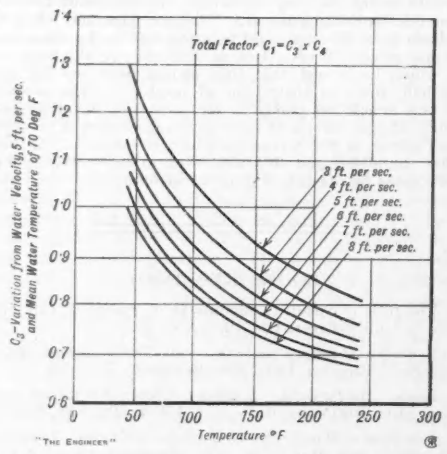


FIG. 50—CORRECTING FACTOR FOR TEMPERATURE AND VELOCITY

3ft. per second, which, for ¾in. diameter tubes, is above the critical, so that the flow in the tubes is turbulent. This matter is of some importance. If the flow through the tubes is slow enough to be streamline, the rate of heat transmission suffers owing to the fact that the "core" of water moving along the centre of the tube never comes into contact with the walls, and has, therefore, little influence upon cooling them. Owing to the fact that the heat conductivity of water is low, only the outer annular ring of the water flowing through the tube is heated. When, however, the rate of flow is so increased as to become turbulent, every drop of water at some time comes into contact with the tube, which is consequently more rapidly and effectively cooled. Fortunately, the rates of flow necessary to exceed the critical are not very high. They depend upon the temperature of the water and the diameter of the tube. For a ¾in. tube the lowest allowable velocities at 50 deg. and 80 deg. Fah. are, for instance, about 2·25ft. per second and 1·9ft. per second respectively. In modern condensers velocities of about 5ft. per second are quite normal, but in certain plants of a rather special character, such as the main machinery of warships, it may be necessary to run for long periods at comparatively light loadings. Under such conditions it is necessary for the designer to satisfy himself that sufficient cooling water will be circulated to maintain a velocity in the tubes above the critical.

Resistance to Water Flow.—Since the rate of heat transmission from tube to water increases as the velocity of flow through the tubes is increased, it might be expected that much higher velocities than about 5ft. per second would be adopted by condenser manufacturers with the object of reducing the cooling surface required for a given duty. Unfortunately, however, the power required to force the water through the tubes rises more rapidly than the rate of heat transmission, and some kind of balance must be struck which will give the most economical arrangement.

The loss of head by friction when water flows through tubes at velocities above the critical is a subject which is dealt with fully in standard works upon "Hydraulics," and it is therefore unnecessary and undesirable that it should be fully considered here. The main resistance to the flow of water in a condenser circulating system arises within the condenser itself, and may be conveniently divided into three parts—that due to the tubes, that due to entrance and exit to and from the tubes, and that due to the alteration in the direction of flow in the water-boxes. In a paper recently read before the Institution of Mechanical Engineers,* the results of numerous experiments carried out by the Metropolitan-Vickers Electrical Company, Ltd., on this subject were presented. It is suggested that the total friction loss in the condenser can be calculated from the formula:

$$H = n\left(C_1 \frac{L}{2g} \frac{V_t^2}{D} + C_2 \frac{V_t^2}{2g}\right) + C_b \frac{V_b^2}{2g}$$

in which n is the number of flows: L the length of tubes in feet; D the diameter of the tube in feet; V_t the mean velocity in feet per second of the water passing through the tubes, and V_b the velocity throughout and in the outlet branches of the water-box. The first term represents the tube loss, the second the entry and exit losses, and the third the water-box losses. Values for the three constants C_1, C_2, and C_b were determined as a result of a long series of experiments. C_2 varies according to the type of tube fixing adopted, and has the values tabulated below:

Tubes ferruled at both ends	1·5
Tubes bell-mouthed and expanded at entry; ferruled at exit	1·25
Tubes bell-mouthed at entry; expanded at outlet	1·0

Owing to the difficulty of determining water-box loss by direct tests, it is suggested that the value of C_b should be taken conventionally as unity, and that the same value should be used when tests are made of actual condensers for the purpose of determining C_1. A value of C_1, equal to 0·030 is suggested as applicable to condenser tubes cleaned by wire brushing, and accords well with the experimental results shown in Table XV. This value, however, only applies for a cooling water temperature of 70 deg. Fah., and a velocity of 5ft. per second through tubes ¾in. external diameter, 18 I.W.G. The correcting factors by which it must be multiplied for differences in temperature and velocity, and in tube

TABLE XV.—*Tests Results of Measurements of Condenser Water Side Friction.*

Installation.	1 Liverpool.	2 Stalybridge.	3 Priestmans.	4 Edinburgh.	5 Clydes Mill.	6 West Ham.	6 Edinburgh.	8 Edinburgh.
Condition of tubes	Wire-brushed	Wire-brushed	Wire-brushed	Brushed	Not brushed. Boiled out with soda	Dirty	Dirty	Dirty 4 months later
Number of flows	2	2	2	2	2	2	2	2
Length of tubes, ft. in.	16 0	15 6	14 0	16 0½	18 0	15 0	14 6	14 6
Outside diameter of tubes, in.	¾	¾	¾	¾	¾	¾	¾	¾
Gauge of tubes, I.W.G.	18	18	18	18	18	18	18	18
Tube packing, in	Ferruled	Ferruled	Ferruled	Ferruled	Ferruled	Ferruled	Ferruled	Ferruled
Tube packing, out	"	"	"	"	"	"	"	"
Total resistance, ft. water	10·61	6·32	9·30	12·91	13·675	17·63	14·90	14·10
Velocity through tubes, ft. per sec.	5·46	4·10	5·80	6·096	6·85	6·08	5·72	4·75
Velocity through branches, ft. per sec.	8·70	6·75	4·98	8·20	5·68	7·25	5·43	4·50
Mean water temperature, deg. Fah.	94·5	64·0	82·25	62·57	62·66	81·08	54·0	68·55
Friction coefficient C_1 corrected to 70 deg. Fah. and 5ft. per sec.	0·0322	0·0304	0·0288	0·0306	0·024	0·0521	0·0455	0·067
Circulating water	Cooling tower	Cooling tower	Cooling tower	Sea water	River water	Estuary	Sea water	Sea water
Remarks							Tube plates cleared of mussels.	

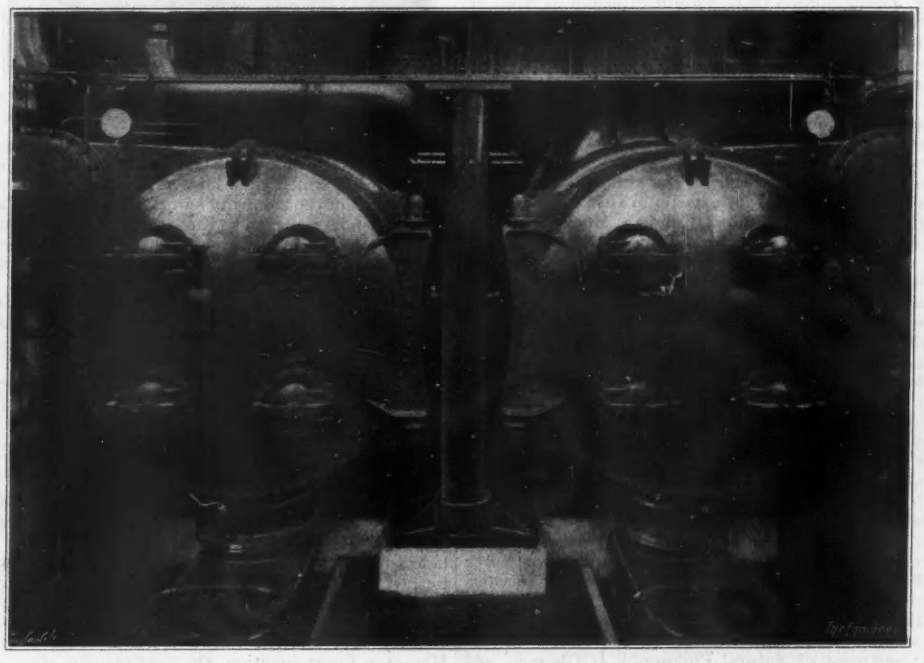


FIG. 51—HICK HARGREAVES CONDENSERS WITH HINGED WATER-BOX DOORS

* "Some Factors in the Design of Surface Condensing Plant," by Guy and Winstanley, "Proc.," I. Mech. E., 1934.

diameter respectively, are shown in the graph reproduced in Fig. 50 and the Table XVI.

TABLE XVI.—*Correction Factor for Variation in Tube Size.*
Basis : 5ft. per sec.; 70 deg. Fah.; tubes ¾in. outside diameter and 18 I.W.G.

Outs. diam., inches.	Thickness, I.W.G.	Factor C_4.	Outs. diam., inches.	Thickness, I.W.G.	Factor C_4.
⅝	16	1·067	⅞	16	0·971
	18	1·055		17	0·965
	19	1·049		18	0·959
				19	0·953
¾	14	1·024	1	16	0·936
	16	1·012		17	0·930
	18	1·000		18	0·924
	19	0·994		19	0·918

SYPHONIC INSTALLATIONS.

The availability and situation of water supplies have perhaps more effect upon the general design of a surface condenser for any particular installation than any other single factor. If very large quantities of water are available and can be pumped cheaply to the condenser, the vacuum that can be obtained may be high, whereas a restriction upon the quantity

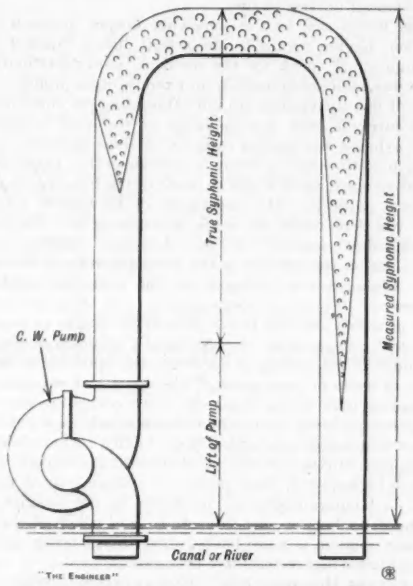


FIG. 52—SYPHONIC CIRCULATION SYSTEM

available will necessitate the adoption of a lower vacuum. The power required to pump the water to and from the condenser must also be brought under consideration, since it would be easy to waste in pumping losses all the additional gain resulting from the adoption of a high vacuum. In this connection the arrangement of the circulating water circuit as a syphon which carries water over some obstacle from one reservoir to another at a lower level. The discharge is dependent upon the difference in level of the two reservoirs, modified by the effect of friction losses in the piping. Clearly, since atmospheric pressure amounts to about 34ft. head of water, the top of the syphon cannot be at a level greater than 34ft. above the surface of the water in the upper reservoir. In practice, in fact, the limit usually occurs at about 25ft. Condenser designers, however, build syphonic systems up to 36ft. in height and make them operate!

The apparent anomaly can be traced to the manner in which the height of the syphon is measured. In the case of a condenser installation water is drawn from and discharged to one and the same reservoir—usually a canal, a river, or the sea. Circulation is maintained by a pump whose duty is merely that of overcoming friction losses in the circuit and not that of lifting the water to the highest point. But when a syphonic system includes a pump, the measurement of the height of the syphon above the water level in the reservoir does not give a correct impression of the syphonic lift. The state of affairs can best be visualised by supposing the pump to lift the water from the reservoir into a tank into which the suction leg of the syphon dips. Then the true syphonic lift is the height of the top of the syphon above the tank, which is equivalent to the height of the syphon above the reservoir less the head developed by the circulating pump. When a condenser designer speaks of a 36ft. syphon he refers to the vertical height of the syphon over reservoir level. The real height of the syphon is only about 25ft. or so.

If it was assumed that the water passing over a syphon was deaerated, its discharge could be calculated from a knowledge of the difference in level of the two reservoirs and the friction loss in the piping. In practice, however, the water contains dissolved air, which, owing to the reduction in the absolute pressure, comes out of solution as the top of the syphon is approached. So long as the velocity of flow is sufficiently high, this effect will not "break" the syphon, since the bubbles of air will be entrained in the water and carried down the discharge pipe. But on the discharge side there has been a loss of absolute pressure, owing to friction in the pipe, and, moreover, in a condenser system the outlet water is warmer than the inlet water. Both these effects will delay the reabsorption of the air into the water. Consequently, in the length of the discharge leg, as indicated in Fig. 52, there is an appreciably greater volume of free air present than there is in the corresponding length of suction leg. In fact, length for length the mixture of air and water on the suction side is denser than that on the discharge side. Of course, despite the disparity in density, the syphon will still operate if the discharge leg is sufficiently the longer of the two; but in comparison with the ideal syphon using distilled water, its discharge will be less by an amount corresponding to the loss of head produced by the difference in density of the mixtures in the two legs. This loss of head is usually expressed as an efficiency. Thus, if a plant is said to have a syphonic efficiency of 97 per cent., that indicates that the "pulling" power of the discharge leg is only 97 per cent. of that of a column of deaerated water of the same length. The loss of head involved must be made up by the circulating pump.

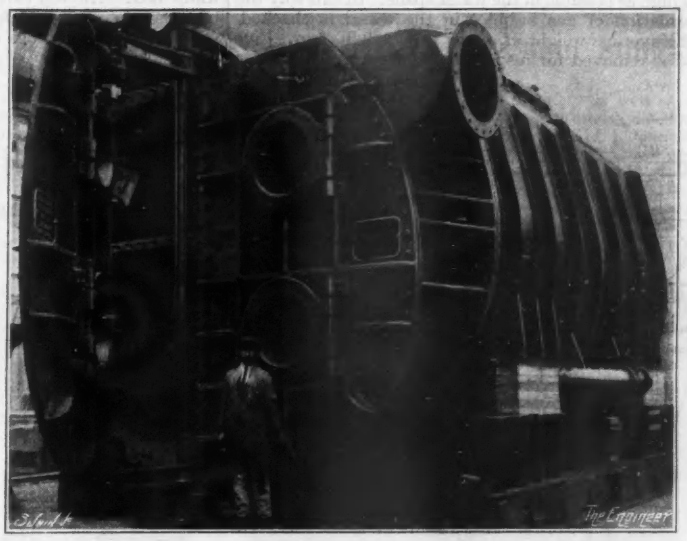


FIG. 54—METHOD OF SWINGING DOOR ON RICHARDSONS, WESTGARTH CONDENSER

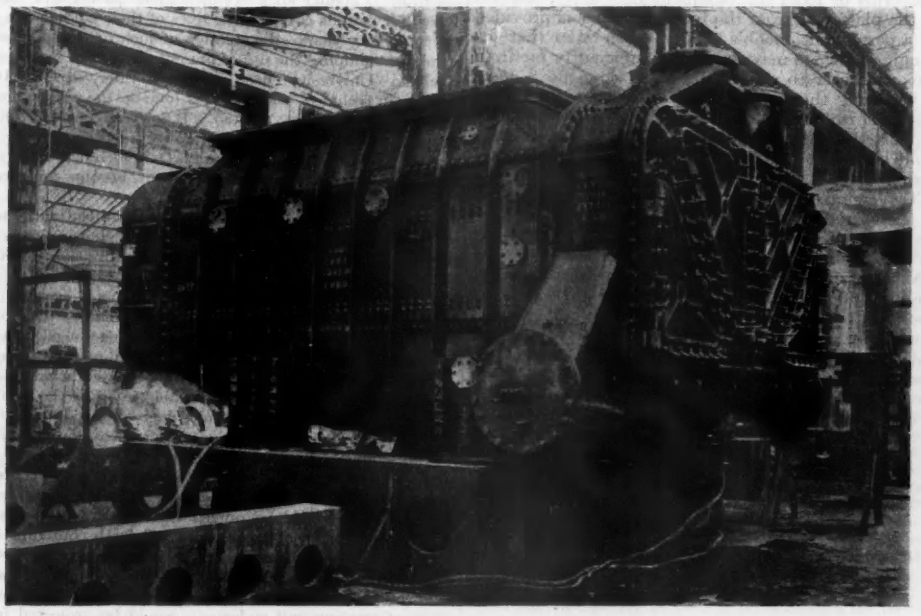


FIG. 53—JOHN BROWN-WEIR CONDENSER WITH SPECIAL HINGED WATER BOX DOORS

CLEANING OF TUBES AND TUBE PLATES.

Referring back to Table XV, it will be seen that there is a very considerable increase in the value of C_1 when the tubes are dirty—see columns 6, 7, and 8. Such conditions obviously add to the power necessary to pump the water through the tubes. But dirty tubes have an even more damaging effect upon the rate of heat transmission. Tests at Barton power station established that the effect of fouling was to reduce the heat transmission rate by 40 per cent. after 800 hours of service since the tubes had last been cleaned. The rate at which fouling occurs depends, of course, on the nature of the cooling water. The surface condensing plant originally installed by the Edinburgh Corporation, for instance, operated with water taken from one of the main sewers of the city and in consequence many troubles were experienced, notably from material of a fibrous nature which rapidly formed a mat over the tube plates of the condensers. It was, in fact, no unusual experience to have to clean each condenser several times in twenty-four hours! But the actual amount of "tubing" done was small. The Portobello station of the same Corporation draws its cooling water from the sea, and it is found that at certain periods of the year mussel shell tends to accumulate on the tube plates. During the spring the precaution is taken of heating the outlet water to a temperature of about 90 deg. Fah. for a period of twelve to fourteen hours. This action has the effect of making the mussels vacate their shells, and consequently let go their hold on the walls of the pipe work. Nevertheless, the accumulation of empty shell necessitates that regular cleaning shall be done. Various means have been adopted at different times to deal with the cleaning of the 5000 tubes in each condenser. A hydraulic piston projecting rubber balls by the use of a pressure of 50 lb. to 75 lb. per square inch was tried, but rejected, owing to the fact that the operator was very soon soaked to the skin. Several different types of brushes were used with a varying degree of success. Then a pneumatic pistol was obtained, together with a supply of brush bullets. But the latter, it was found, frequently jammed in the tubes. At present the rubber balls originally used with the hydraulic pistol are projected through the tubes by the pneumatic one, the pressure used being 75 lb. to 100 lb. per square inch. To clean two condensers — 10,000 tubes — takes approximately 96 man-hours.

At Barking "A" station there are twenty-four shells, each containing 10,500 to 11,000 square feet of cooling surface. The cooling water is drawn from the mouth of the river Thames and fouling is found to occur principally in winter and spring and to a lesser extent in summer and autumn. In a dry winter fouling is below normal, and in a wet summer above normal for the time of the year. The water is chlorinated during the periods when fouling occurs, and the tubes are brushed occasionally with bristle brushes on rods. The effect of chlorinating the water has been to increase the intervals between brushings three or four times. It changes slime into a less viscous mud, which is more easily washed away. The main advantage of the pistol and bullet method of cleaning tubes is that only the subsidiary doors on the

main condenser doors need be opened, with a consequent saving of time. As, however, at Barking it is necessary in any case to remove the doors, the brush has been adopted. It has the advantage that, whereas a bullet passes only once through the tube, the brush passes twice, once in each direction.

The engineer at Barking station has also provided us with some interesting figures regarding tube corrosion. The tubes are Admiralty mixture and failure of those few which have had to be replaced has been due to cracks developing. Circulating water is fed from a common bus pipe and all inlet valves remain wide open except while tube cleaning is in progress. If the turbine is running light or is being run up to speed the flow of water is throttled on the outlet valve so that the pressure shall be maintained as high as possible in the water space. In this way the formation of gas bubbles in the water is checked. The average weight of a new tube is 9 lb. 5 oz. Five tubes removed for inspection after six years' service weighed 8 lb. 8 oz., 8 lb. 2 oz., 8 lb. 8 oz., 7 lb. 14 oz., and 8 lb. 4 oz., respectively, the reduction in weight being accounted for by general internal corrosion.

A type of action that more rapidly leads to failure of a tube is erosion at the inlet end. According to experience at the Portobello station, the occurrence of erosion has some connection with the design of the water box. In four condensers at that station the water enters the inlet box from the side; and in another group of four it enters at the bottom. Whereas no erosion has occurred in these condensers which have side entry, it has been sufficiently severe in the condensers of the other group to necessitate the reversal of a number of the tubes. The explanation is offered that the bottom entry causes pronounced eddying of the water, which releases air in solution to such an extent that the inlet ends of the tubes are eroded by the impingement of air bubbles.

Examples of this kind could be quoted for a large number of different stations. In each the engineer has special problems of his own to face and develops suitable methods of dealing with them. The matter has been dealt with in a number of technical papers descriptive of power stations, to which readers interested in this phase of practice may be referred.

Access to Tube Plate.

The necessity that access to the tube plates for cleaning or replacement of tubes shall be easy influences the design of water boxes and doors. In many cases it is sufficient to provide a number of manholes in the main condenser doors in order to provide for cleaning of the tubes by means of some form of gun and bullet. But for tube replacement the whole door must be removable. Various methods of supporting the door while it is removed are adopted according to circumstances. On smaller plant the whole door may be arranged on a hinge at one side, and in this case a certain degree of "play" is made available in the hinge so that the door may be pulled up without hindrance to make a joint. A typical example of this arrangement can be seen in the engraving Fig. 51, showing twin condensers of Hick-Hargreaves construction. The simplest method is to cast in two lugs near the top of the door, bored to take a bar around which the chain from a crane may be placed. Reference back to engravings in the earlier articles of this series will show that this method is very commonly adopted. Alternatively, as in the Weir condenser for the "Empress of Britain," a photograph of which was reproduced in Fig. 17 (*ante*) and is again printed on this page in Fig. 53, two or more large doors may be hinged on to the main door. They must each be of sufficient size to reveal the whole of one section of the tube plate. This method of construction can only be adopted where the tube plate is divided into convenient sections. In very large plants where there are two main doors at each end instead of one, a vertical rod may be mounted rotatably in lugs cast on the top and bottom of the water box. The rod carries at top and bottom arms bored at the ends, which can swing into engagement with corresponding lugs cast into the main doors on each side. This plan was adopted by Richardsons, Westgarth and Co., Ltd., for their condensers at the Dunston power station, one of which is seen in Fig. 54, reproduced on page 491 from an earlier article.

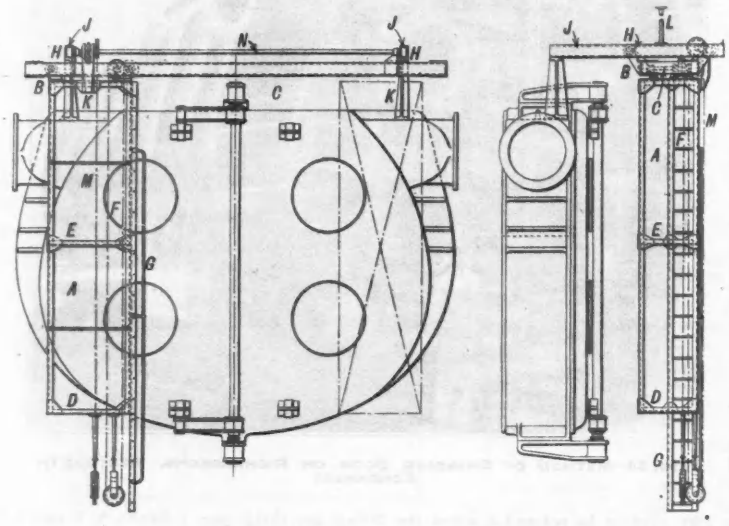


FIG. 55—TRAVELLING CARRIAGE FOR ACCESS TO CONDENSER TUBES

At Dunston power station the uppermost rows of tubes in the Richardsons-Westgarth condensers are no less than 18ft. 6in. above floor level. The firm therefore provided special travelling platforms, by the use of which access could conveniently be gained to the tubes. The arrangement of the device can be seen in the line engraving Fig. 55. There is a carriage A fitted with bogie wheels B, by which it is suspended from and enabled to travel across the main runways C. The length of the runways and the vertical dimensions of the hanging carriage are such that the whole area of the main condenser doors and consequently of the tube plates can be covered. The hanging carriage is provided with a lower platform D and an intermediate platform E, located at levels which facilitate manipulation of and access to the inspection doors on the main condenser doors. The carriage is traversed along the runways by the hand chain F, which can be operated from either of the platforms or from the basement floor level. Access to the platforms from the basement floor is provided by a permanent Jacob's ladder G. In order that the hanging carriage may be moved sufficiently far from the condenser to enable the main condenser doors to be swung the main runways C are carried by bogie wheels H running on subsidiary runways J, which are supported at one end by brackets K from the water head and near the other end by stays L from the turbine floor steel work.

Traversing on the runways J is effected from either of the carriage platforms or from the basement floor by means of the hand chain M and square shaft N. In the Fig. the hanging carriage is shown at its maximum distance from the condenser, but it will be readily understood that when either main condenser door has been swung the carriage may be traversed towards the corresponding half of the tube plate until its further progress is limited by proximity to the main condenser door studs, and in this position on the runways J it may be traversed on the runways C over the whole half width of the condenser.

(To be continued.)

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

UNIVERSITY DEGREES IN ENGINEERING.

SIR,—The comparative survey of the conditions under which engineering degrees are granted in the universities of this country will be of service not only in providing information otherwise obtainable only after laborious search in the often irritatingly obscure university calendars (and one could wish that it could be eventually available in pamphlet form), but also in drawing attention to the general question of technical qualifications in engineering.

I venture, however, to take exception to the statement in the leading article introducing the survey that "the right to inscribe B.Sc. after one's name means by itself little or nothing. It may imply that the holder has, solely by attending evening classes, just managed to scrape through certain examinations."

Many of your readers will, I fancy, be prepared to take off their hats to the man who, "solely by attending evening classes," has managed to cover the external syllabus of, say, the London B.Sc. (Eng.), and pass the by no means negligible final examination, and some will consider that a young engineer with the grit and determination to follow such a course to a successful conclusion is possessed of qualities likely to stand him in good stead in the profession, and will question whether his technical knowledge, co-related as it must be to his practical work during the day, and based as it is on the efficient laboratory instruction associated with evening classes at all our recognised technical colleges, is not likely to be as useful in the practice of his profession as that gained by his more fortunate competitors who, possibly by reason of easier circumstances, have had the advantage of three or four years' full-time study in a university, and who may not have seen the inside of an engineering workshop until its conclusion. Some might even go further and ask whether a pass degree obtained under the more arduous conditions is not a more satisfactory qualification than an honours degree gained, as I know from my own experience, under the far easier conditions of university life.

This brings one to the somewhat deeper question of whether, having regard to the actual duties required of an engineer (I speak for the moment more particularly of the mechanical engineer) in the exercise of his profession, some of the universities are not attempting to crowd into their curricula such a wide range of technical subjects as to exhaust the mental capacity of their students and to leave no time for the study of the elementary principles of management upon which so much of the future of these students depends. The Institution of Mechanical Engineers has done useful service in introducing into the pre-graduateship portion of its Associate Membership Examination the subject of the Fundamentals of Industrial Administration, followed by the post-graduateship subject of Workshop Organisation and Management, both of which are now being extensively taught in many technical colleges under the National Certificate Scheme. It would be interesting to ascertain the opinions on this point of some of your readers who have had experience in dealing with young engineers, both college graduates and others, in their works, and to know whether for general works administration, apart from highly technical and specialised duties, for which, of course, the expert will always be required, they prefer the college-trained man with an honours degree or otherwise, or the product of the harder school of part-time study, and which of these, in their opinion, is more likely, other things being equal, to qualify for higher executive positions.

FIRST-CLASS HONOURS B.Sc. (ENGINEERING) LONDON.

November 12th.

SIR,—The suggestion of Mr. Arthur Devon, in your current issue, to establish three degrees, viz., B.Sc.T., M.Sc.T., and D.Sc.T., respectively, to qualify for different grades of endeavour in engineering pursuits, might be very good if a start with the establishment of degrees were just being made. As it is, however, they would only serve to complicate still further the issue. For since it is essential to honour all previous degrees earned and conferred for periods covering the lives of their holders—say up to seventy years—the creation of such further degrees would not simplify the use of present ones. For instance, Sheffield University has conferred thirty-one Ph.D. degrees in technical science so far (one on the writer) and has already, as you have noted, a B.Sc. Tech. degree. The proposed B.Sc.T. would be merely regarded as an abbreviation for B.Sc. Tech., and the Ph.D. in technical science, as well as D.Sc. Tech., already existent, become confused with the proposed D.Sc.T.

The most thorough and efficient way to deal with the whole problem—which is not confined to engineering alone—seems to be to establish a Degrees Stabilisation Board. This would have members from administration, instructing, and student (graduate or post-graduate) aspects of university life, supplemented by members from the professions. Rationalisation would be introduced—such abstract rationalisation, divorced from direct economic considerations would injure none—by deciding what total number of degrees should be available covering the whole field of knowledge; what definite degrees of such totality should reward or hall-mark given problems or labours, within definite faculties; and these generic standards would be observed by all British universities. Three desirable effects would be produced, viz., (1) dignity and national force would be ranged behind all degrees; this tends to be weak enough now to call forth contempt in some quarters, because individual universities compete rather than unite in safeguarding this, their greatest, most obvious, common credential; (2) a clear-cut hall-mark of learning and endeavour would be projected for the assessment of all men, professional or otherwise, without the subjective implications of high education being belittled; degrees, in general, would become more valuable because more definite criteria, and because the present hazy mix-up of the present public mind would be replaced by readily perceived standards; and (3) the present frequent efforts to magnify small differences in curricula and degree ordinances from university to university, into serious differences of level in academic distinction embodied in the resultant degrees, would be

exposed as an insufficient basis for differentiation which is often now applied, both in academic and professional and business circles. These slight, greatly magnified minutiæ would be rolled out, but no interference with individual university administration would be contemplated by such a Board.

S. C. BLACKTIN.

Leeds, November 9th.

THE SURFACE CONDENSER.

SIR,—I note with particular interest the illustrations and description of the Allen-Leeds condenser in the issue of your journal for November 2nd. I am writing you, as it seems to me that your readers will infer from the description that this condenser was specially designed by Allens to meet the Leeds conditions, which, of course, would not be correct. This special design was developed by the Mirrlees Watson Company in collaboration with the then Leeds City Electrical Engineer, the late Mr. H. Dickinson, in 1904, and altogether we supplied Leeds Corporation with eight sets of plant embodying the same features. The first condenser was designed for a single flow only, the water being delivered into a very deep open top water box, thus giving access to the cleaning of the tubes by brushes while the plant was in full operation. The circulating valves and piping were so arranged as to give reverse flow as desired.

The later condensers were designed to give either a single downwards or a two-course down and up flow, this being attained by a central division plate and a sliding door, similar to that in the Allen condenser; also provision is made for reversing the flow. I think it would be only fair to make a reference to our association with this design, seeing that we supplied all these condensers before the one installed by Messrs. Allen. If we were now asked to repeat such an installation, we should, of course, adopt a different shape of condenser, having dimensions wider and shorter in depth, and we should space our tubes on the Mirrlees-Delas principle.

W. A. DEXTER,
Glasgow, Nov. 5th. The Mirrlees Watson Co., Ltd.

[We regret that owing to an oversight we made no mention of the Mirrlees Watson Company in this connection.—ED. THE E.]

The Weaver Valley Transmission Line Crossing.

THE 33-kV ring main owned and operated by the Mid-Cheshire Electricity Supply Company, Ltd., crosses the Weaver valley, over half a mile wide, at Wallerscote, near Northwich. Owing to projected works in the valley, involving the provision of a dump to be eventually about a mile long and 50ft. to 80ft. high, which will absorb all the clearance on the lines leading to and from the crossing, it was necessary to move and reposition about 1 mile of line. A crossing point about half a mile downstream from the original point of crossing was eventually chosen, where the physical conditions might assist in providing an economic solution.

The main conditions laid down were a minimum clearance of 70ft. over the Weaver Navigation, to allow for masts and derricks of boats, and 30ft. over an embankment not yet erected. These governing conditions for clearance occur roughly at points about equidistant from each end of the span and each other. Schemes for a division of the valley crossing into two or three spans were investigated and rejected on several grounds.

Since it was necessary to find a conductor that would give a most economical combination of weight, sag, and area exposed to wind loading, while withstanding the atmospheric conditions of the district and in a valley which is subject to brine storms, the choice was a matter of some difficulty.

Aluminium had previously proved unreliable in the valley, but copper had stood well. Sags for standard copper, cadmium copper, and the usual standard steel-cored copper conductors, of 0·075 square inch equivalent, were worked out and found to necessitate unduly high towers and excessive spacing. Phosphor bronze which had been used previously with success on the old river crossing of about 550ft. would have involved an excessive cost. Two courses, then, remained—either to use a large standard copper or cadmium copper conductor or a specially designed steel-cored copper conductor. The first alternative gave excessively high towers, unless very much larger conductors than necessary were used, *e.g.*, 0·15 square inch cadmium copper, but in the case of steel-cored copper it was possible to vary the number and diameter of wires and the ultimate strength of the steel in the core within wide limits.

The final choice was a 0·075 square inch copper equivalent steel-cored copper conductor specially designed by the contractors in collaboration with the Whitecross Company, Ltd., of Warrington.

It is made up as follows:—18/0·0705in. diameter hard-drawn copper strands round 19/0·0705in. diameter galvanised hard-drawn steel strands (ultimate strength, 115 tons per square inch).

The physical constants of this conductor are:—

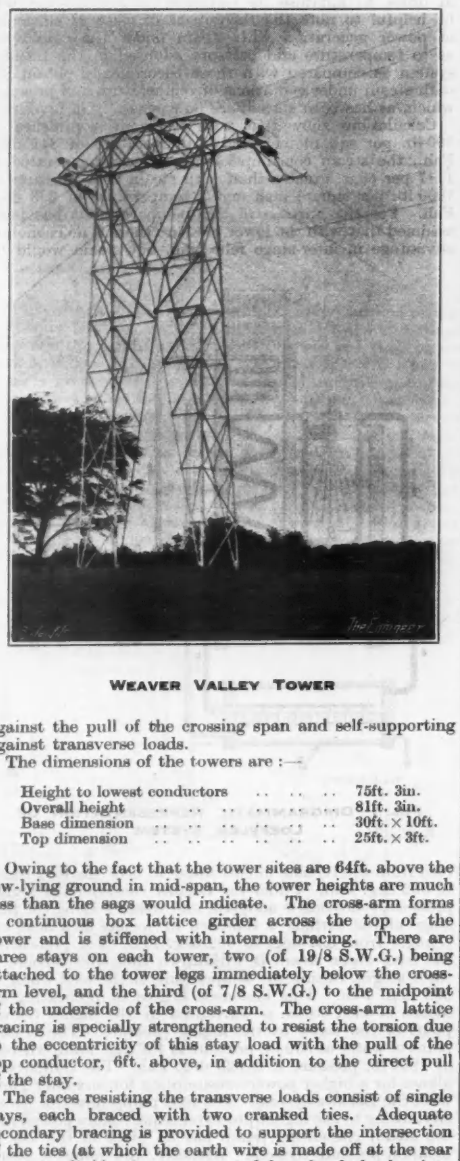
Diameter	0·497in.
Weight per foot	0·5409 lb.
Virtual combined modulus of elasticity (E)	$23 \cdot 13 \times 10^6$ lb./sq. in.
Virtual combined coefficient of expansion (α)	$7 \cdot 468 \times 10^{-6}$ per deg. F.
Ultimate strength	20,348 lb.

The high value of E and low value of α indicate a conductor of small variation in sag with change of loading or temperature. The corresponding values for a 0·075 square inch S.C.A. conductor used on the secondary lines of the C.E.B. are:—$E = 12 \cdot 49 \times 10^6$ lb. per square inch, and $\alpha = 10 \cdot 74 \times 10^{-6}$ per degree Fah.

It was decided to string this span to the Electricity Commissioners standard loading, but to provide a safety factor of 2½ instead of the minimum of 2. The maximum sag at 122 deg. Fah. in still air is 80ft. approximately, while the minimum at 22 deg. Fah. in still air without ice is 73ft. approximately, *i.e.*, a variation between extreme conditions of only 7ft. The corresponding variation on a similar span for the S.C.A. conductor mentioned above would be about 10ft. 6in.

On the north side of the crossing span the tower carries a small angle line (at greatly reduced tension) terminating on the terminal support of a wood pole line, while the south tower carries an angle of 68 deg. with a span of 1000ft. to a steel tower. These adjacent spans are fitted with earth wires below the line conductors, no earth wire being provided in the long span. The conductors and earth wire in the adjacent spans are 0·075 square inch steel-cored copper (8/0·109 copper round 7/0·060 steel), with an ultimate strength of 9100 lb. The conditions made it impossible to follow the usual practice of fitting suspension insulators on the long span towers anchoring the special conductor at strain towers of normal height.

Having in view the conditions stated, it was necessary to make the long span supports of sufficient strength to be used as section towers. The factor of safety in the long span being greater than that in the shorter spans adjacent, it was deemed advisable to allow for the possibility of all four wires in the spans leading away from the crossing being broken at once, and the large towers were accordingly designed to withstand this condition. The disposition of conductors in the crossing span was finally arranged for a horizontal spacing of 45ft. and a vertical spacing of 6ft., the top conductor being placed centrally. In order to avoid excessively overhung cross-arms with this arrangement it was necessary to use very wide towers. After several trial designs had been investigated, it was decided to use rectangular towers, as illustrated, stayed



WEAVER VALLEY TOWER

against the pull of the crossing span and self-supporting against transverse loads.

The dimensions of the towers are:—

Height to lowest conductors	75ft. 3in.
Overall height	81ft. 3in.
Base dimension	30ft. × 10ft.
Top dimension	25ft. × 3ft.

Owing to the fact that the tower sites are 64ft. above the low-lying ground in mid-span, the tower heights are much less than the sags would indicate. The cross-arm forms a continuous box lattice girder across the top of the tower and is stiffened with internal bracing. There are three stays on each tower, two (of 19/8 S.W.G.) being attached to the tower legs immediately below the cross-arm level, and the third (of 7/8 S.W.G.) to the midpoint of the underside of the cross-arm. The cross-arm lattice bracing is specially strengthened to resist the torsion due to the eccentricity of this stay load with the pull of the top conductor, 6ft. above, in addition to the direct pull of the stay.

The faces resisting the transverse loads consist of single bays, each braced with two cranked ties. Adequate secondary bracing is provided to support the intersection of the ties (at which the earth wire is made off at the rear faces) to divide the unsupported length of the leg into suitable panels, and to ensure that the ties remain sufficiently stiff. In accordance with the Commissioners' regulations, earth bars are provided for the long span, together with duplicate insulators. In view of the large spacing, these earth bars are of unusual type for a steel tower line. A separate earth bar is provided for each conductor, and is secured to the underside of the cross-arms, which are cranked downwards for the bottom conductors and upwards for the top conductor. The whole of the galvanising was carried out with great care.

In order to interfere as little as possible with the power line and the Weaver Navigation in the valley, the conductors were run out during the night and finally regulated at daybreak. The Post Office line was put underground.

The towers, &c., were designed by Watshams, Ltd., Windsor House, Victoria-street, London, in consultation with Mr. W. Fennell, chief engineer and general manager of the company, and were constructed by Joseph Parks and Son, constructional engineers, of Northwich. The special span conductors were prepared by the Whitecross Company, Ltd., of Warrington.

The suspension insulators and the supporting fittings and arcing horns and the clamps were supplied by Steatite and Porcelain Products, Ltd. There are two strings of four insulator units (type S: 325) in parallel with a dry flash-over value of 300 kV and a wet flash-over value of 235 kV. The ultimate strength of the conductor is 20,348 lb., that of each insulator 28,000 lb., the ultimate strength of each set of two in parallel being 56,000 lb. There is thus an insulator factor of safety of about 2¾ under conditions of breakage of the conductor and a working factor of safety of about 5½.

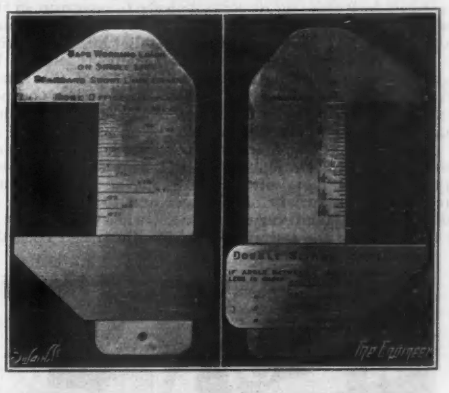
This insulator, which is the same as that used on the Thames crossing, where each set consists of three strings in parallel, is of the spring ring type. The terminal clamps are of a special compound-filled cone pattern supplied by the same company. The whole of the work on the crossing and the adjacent diversion was carried out by Watshams, Ltd., under the supervision of the Mid-Cheshire Company's engineers.

Caliper Gauge for Chain Slings.

ETERNAL vigilance is the price of safety as well as of liberty. Most large works to-day do their utmost to ensure freedom from casualty by the provision of high-grade lifting tackle and by stringent regulations as to its safe use.

In well-regulated works it is customary to exhibit tables giving the safe working loads of chain slings at various included angles. Such information is of necessity confined to one location, while slings are transferred at need from job to job throughout the works, so that there is always a liability that slings and other tackle may be overloaded.

To ensure that, wherever used, a sling of appropriate strength shall be employed, E. Baylie and Co., Ltd., makers of chain and chain slings, have devised the very useful pocket caliper gauge here illustrated. So provided,



CALIPER GAUGE FOR CHAIN SLINGS

there can be no excuse for the actual slinger to select a sling of insufficient strength.

On the front side the caliper reads in safe working loads on the single chain in tons, and on the reverse side the caliper reads in parts of an inch. For double-legged slings there are multiples given on the reverse side of the slide which will give the safe working load on the double slings when used at various angles. Such a pocket device has long been needed, and in the interests of safety F. Baylie and Co., Ltd., supply the caliper post free at actual cost (8s.).

It is understood that the caliper has been submitted to H.M. Home Office, which is exhibiting a sample at the Home Office Museum of Industrial Safety at Horseferry-road, Westminster.

New Boiler Plant at the Hams Hall Power Station.

THREE powdered fuel-fired boilers and two stoker-fired boilers are being supplied by International Combustion, Ltd., of Derby, for the extensions to the Hams Hall power station, Birmingham. All the boilers will have a normal continuous evaporation of 250,000 lb. per hour and a peak evaporation of 300,000 lb. The stop valve steam pressure will be 375 lb. per square inch, and the steam temperature 730 deg. Fah. Constructed on the three-drum Lopulco principle with vertical tubes, each unit will have, in addition, a superimposed steam receiver and a header drum to feed the water-cooled combustion chamber, having Murray fin tubes on the side and rear walls. Tubes are to be arranged on the front wall suitably placed to follow the contour of the burners, but covering up as much refractory as possible. A water screen of spaced bare tubes is also being provided to cover the ash hopper. The main drums will be solid forged with swaged ends. A superimposed steam receiver will be connected to the steam and water drum by a series of tubes. M.L.S. type superheaters with a heating surface of 7050 square feet will be arranged between the first and second passes in the boilers. No economisers are to be provided for the pulverised fuel-fired boilers, but an Usco air preheater, composed of two units, will be employed to reduce the leaving gas temperature to 290 deg. Fah. at normal load, the heating surface of this unit being 48,000 square feet. Two induced draught and two forced draught fans will be provided for each boiler, and will be driven by constant-speed motors through variable-speed hydraulic couplings. By means of relay apparatus, operating in accordance with the draught in the combustion chamber, the induced draught fan will be automatically controlled according to the combustion requirements. Dust collectors will be provided on the suction side of the double inlet induced draught fans.

Each boiler will have its own chimney stack, but dampers

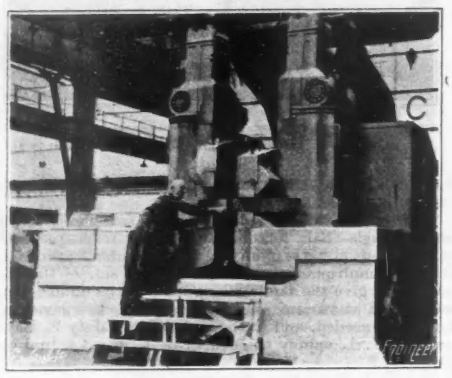
will be provided to enable the gases to be led to a flue connected to an electrostatic precipitation plant, which will deal with the gases under normal operating conditions. The powdered fuel burners will be of the Lopulco short turbulent "R" type, and a certain proportion of the hot air supplied to them will be tapped off for coal drying in the mills and for conveying the powdered fuel to the burners. Five Attritor mills will be provided for each boiler, and will be arranged for direct firing. Each equipment will actually consist of a pair of mills operated by a constant-speed motor situated between the two units.

The two stoker fired boilers will be fitted with Usco travelling chain grate "L" type stokers, 31ft. long by 20ft. wide, and will be supplied with preheated air. The boilers will be complete with superheaters, draught plant, air heaters, and economisers, and the gases will be discharged into the individual boiler chimney stacks. The five new boilers will be placed in line with five existing boilers of 228,000 lb. per hour capacity, which are also fired on the International Combustion Company's "Lopulco" system.

A Large Automatic Butt Welder.

THE universal fully automatic flush butt welder, shown in the accompanying illustration, is claimed to be the largest so far constructed. It was built by the A.E.G. Electric Company, Ltd., and is suitable for the manufacture of heavy anchor links and for welding large pipes to flanges, &c. The increasing use of alloyed steel, such as nickel and chrome, has called for automatic control which will ensure that the weld is made at the moment when the correct upset temperature is obtained at the faces of the metal pieces to be welded in order to avoid burnt or "frozen" joints. Both of these troubles are well known, and, realising that they are liable to discredit the butt welding process, the A.E.G. designed an automatic welder which relies for its control on the temperature of the weld. As the work is preheated before flashing occurs, the rush of current as compared with that associated with a cam or hydraulically operated machine is said to be greatly reduced. The intermittent rating of the transformer is only 800 kVA and will give a continuous output of 400 kVA to weld the maximum area of 40 square inches in 16¼ minutes with a consumption of 47 units.

Single purpose welders for mass production work do not call for alteration of the "burn-off" and upset pressure, but more often than not the machines are required for a variety of purposes and to weld parts of different areas and varying sections when adjustment is essential. On the universal machine illustrated both the



LARGE AUTOMATIC BUTT WELDER

upset pressure and burn off can be adjusted in a few moments by simply turning a pointer and without any alteration of gear wheels or cams. The maximum clamping pressure is 70 tons and the maximum upset pressure 50 tons, and both are adjustable for sections down to 4 square inches, which is the smallest area that can be conveniently handled in this large machine. The rating adopted on these welders is naturally based on the maximum demand of the user, which in this case was that the machine should be capable of welding 40 square inches about three times an hour when the metal lost in burning off or flashing is $2^{3}/_{16}$ in. The machine will weld metal of 20 square inches twelve times an hour with a consumption of 9·2 units for each weld, burning off $1^{21}/_{64}$ in.

The automatic controls are mounted in an enclosed switch cubicle entirely separate from the machine, and, like the transformer, are protected from flash. Experience of the makers having proved that "all-electric" operation is the most satisfactory, three-phase built-in motors developing a torque that responds instantaneously to the load have been provided for operating the clamps and burn off and upset arrangements. Although the machine weighs 40 tons, it has been designed for precision work. Special attention was paid to the design of the platen guide to enable it to deal with the heavy upset pressure of 50 tons.

BOOKS OF REFERENCE.

Kelly's Directory of the Engineering, Hardware, Metal, and Motor Trades, 1934. London: Kelly's Directories, Ltd., 186, Strand, W.C.2. Price 45s. net.—Business houses throughout the country will welcome the new edition of this valuable reference book. As in past years, the directory embraces England, Scotland, and Wales, the information being arranged as follows:—The names for each county arranged under towns and villages; an alphabetical classification of trades for the London area; an alphabetical classification of trades for the rest of England, Scotland, and Wales; iron and steel sections and their manufacturers; brands on iron and steel work; a list of proprietary articles and trade names.

The Loeffler System of Steam Production.*

By S. McEWEN, A.R.S.M.

WHILE the combustion engineer is constantly striving to obtain higher furnace temperatures in order to secure the benefit of a high rate of heat transmission consequent with a higher heat head, the steam engineer, pursuing a definite course of development, provides higher internal temperatures so that the result of both these efforts is to subject the material of heating surfaces to conditions of greater severity. The following account of the Loeffler system, its development and operation in commercial practice, will show how the new conditions have been effectively met without making exceptional demands on the metallurgist.

Many prominent engineers have expressed their views as to highest practical limits of steam temperature and pressure under present-day conditions, and, while there is naturally some divergence of view, it seems to be most generally accepted that considerations of capital cost, maintenance charges and reliability make it unprofitable to employ steam for power generation at pressures above 600 lb. per square inch and temperatures above 800 deg. Fah. This conclusion is, of course, based on the assumption that water-tube boilers would have to be used for the generation of steam, and ignores the more recent developments in turbine design, which latter have established in commercial practice the complete practicability of the use of pressures and temperatures such as are adopted in the Loeffler system.

Before giving a description of the Loeffler system, and in order to appraise its economic possibilities, it will be helpful to note the theoretical increase in efficiency of power generation with steam under the conditions as to temperature and pressure adopted in the Loeffler system as compared with those theoretically obtainable with steam under conditions of temperature and pressure which, as has been stated, are now generally in favour.

Calculations show that with steam at a pressure of 590 lb. per square inch and a temperature of 842 deg. Fah., the steam consumption per kilowatt generated is 11·7 per cent. greater than with steam at a pressure of 1900 lb. per square inch and a temperature of 896 deg. Fah. For the purpose of this comparison, it has been assumed that with the lower pressure there is no economic advantage in inter-stage reheating, but steam would be

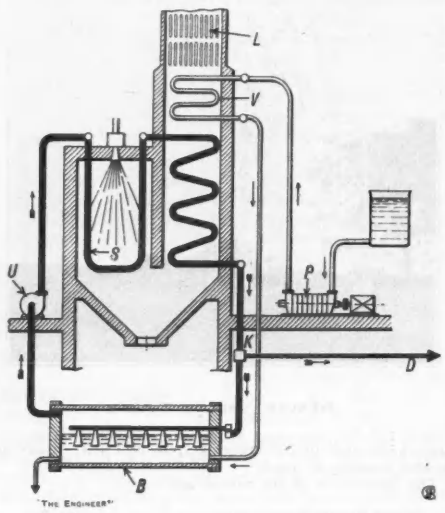


FIG. 1—DIAGRAMMATIC REPRESENTATION OF LOEFFLER SYSTEM

bled from the turbine in two stages to heat the feed water to 302 deg. Fah. Under the Loeffler conditions of higher pressure, reheating is adopted, and steam leaving the first stage of the turbine is reheated by means of a heat exchanger from 537 deg. to 662 deg. Fah. For preheating the feed water steam is withdrawn from the turbine in three stages, raising the temperature of the feed water to 392 deg. Fah. This increased degree of preheating by means of bled steam is warranted by the higher boiling point of the water at the higher pressure. The boiling point of water at 590 lb. pressure is 486 deg. Fah., whereas at 1900 lb. pressure it is 623 deg. Fah. The comparison allows for a higher power consumption for auxiliary plant with the Loeffler system. The feed pump must, of necessity, owing to the higher pressure, require more power, and the steam circulating pump has no place in the low or medium-pressure system. Actually, the reduced steam consumption and the reduced weight of fuel to be handled secure a reduction in the power required for auxiliaries other than those of the feed and steam circulating pumps; but for the purpose of this comparison an additional 3 per cent. of the power generated has been debited against the Loeffler system, being the extra power required for the feed and steam circulating pumps.

The increase in efficiency shown to be theoretically possible is of a substantial character, and as it can be obtained without being subject to a debit for increased capital and other costs, an equally substantial economy will be secured from commercial operation.

Fig. 1 is a diagrammatic representation of the Loeffler system. Referring to this diagram, S is a radiant superheater, lining a combustion chamber; N is a convection superheater; B is a boiler drum placed in any convenient position outside the setting; U is a rotary pump, the purpose of which is to circulate steam, withdrawn from the boiler drum, through the radiant and convection superheaters up to the branch K, at which point a part of the steam passes to the steam mains, while the remainder returns to the boiler drum wherein its superheat is utilised to evaporate more water, the amount to be evaporated being equivalent to that delivered to the steam main. P is a feed pump, while V and L represent the economiser and air heater respectively. It will be observed that one outstanding feature of the system is that all the steam is generated in a drum not exposed to any external heat, while the remainder of the circuit which is exposed to external heat contains only dense, clean and dry steam. With the aid of this brief description, the following technical and economic considerations and advantages of the system may be readily appreciated.

Steam at a pressure of 1900 lb. per square inch has a specific volume of 0·21; where as at a pressure of 600 lb. per square inch the specific volume is 0·76; the density at the higher pressure is 3½ times greater than at the lower. It is this low specific volume which makes it economically possible to circulate the steam by means of a pump.

The successful achievement of the commercial generation of steam at high pressures and temperatures by the Loeffler system has been secured in virtue of four main characteristics of the system.

Steam is the only medium for absorbing the heat which is liberated in the furnace, and this steam in a very dense condition is caused to flow through tubes at a velocity which ensures a small differential in temperature between that of the steam and the metal walls of the tubes. This differential, which can be predetermined by calculation, is such that the metal of the tubes of selected quality can suffer no deterioration. The velocity of the steam, which can be predetermined for any installation, is of the order of 65ft. per second at maximum capacity, and, under these conditions, over 40,000 B.Th.U. are transmitted per square foot of heating surface per hour through the surface of the radiant superheater without any risk of overheating the metal.

The entire absence of scale or deposit on the interior surfaces of the tubes ensures constant conditions for heat transference; no provision has to be made for a progressively reduced rate of transference, as is the case with a water-tube boiler, where the maximum allowable rate of transference must be that which is safe when the tubes are dirty and the boiler due for internal cleaning.

There being an entire absence of water circulation problems, the disposition of the heating surface can be arranged with consideration only for heat transmission. The tubes not being subject to the necessity for internal cleaning, can be disposed without regard to provision for cleaning. The high average rate of heat transmission which is actually obtained in practice, results in a material reduction in the area of heating surface which has to be provided for any given duty as compared with that required for a normal water-tube boiler. This reduction in area more than balances any extra expense per square foot of heating surface involved, in providing for higher pressures. In comparing modern Loeffler installations with modern water-tube boiler installations, it is found that the latter have from 40 to 50 per cent. more pressure heating surface than the former.

It is clear, from the abundant literature on the subject, that with the generation of steam at higher pressures and temperatures in water-tube boilers, the greatest possible care has to be exercised in preparing the feed water, for, owing to the unavoidable existence of some salts in solution, it is necessary to guard against corrosion, formation of a non-conducting scale, and a tendency for salts in suspension in the steam to be carried over into the turbine. For practically every installation the pretreatment of feed water for new conditions of pressure and temperature presents a problem which has to be solved independently, and it frequently happens that considerable expense is incurred or even serious damage done to the boiler before satisfactory conditions are established; even then, safety can only be ensured by constant watchfulness. It will be readily apparent that by the Loeffler principle of steam generation, the condition of the feed water becomes a matter of minor importance. Thus it becomes possible with the Loeffler system to obtain the economic advantages of high pressure and high temperature steam applied to back pressure turbines furnishing exhaust steam for industrial process. In such cases the make-up water may be 100 per cent., and this presents no difficulty. It is, of course, desirable to deaerate the feed water, and where it is possible it is preferable to subject the feed water to chemical treatment in order to avoid unnecessary blow-down losses. The practicability of operating the boiler with a high concentration of solids has been established by very carefully conducted and complete tests. Thus a boiler has been operated over a long period supplied with feed water having a salt concentration of 0·8 deg. Baumé, which is equivalent to 8000 milli-grammes per litre. Samples of steam were drawn from the superheater and found to yield only 10 milligrammes per litre of condensate. The salt concentration in the water was then allowed to increase until it attained 3·5 deg. Baumé; that is, a salt concentration of 35 grammes per litre. The Loeffler boiler worked perfectly satisfactorily under these conditions, and, after 2000 hours' operation some tubes were cut out for examination and found to be entirely free from deposit. These exhaustive tests were made as a preliminary to the adoption of Loeffler boilers for an important chemical works, where process steam was required and no condensate would be available for feed water.

In practically every case in which the Loeffler system is being examined for the first time, attention is focussed on the steam circulating pump. Truly, this is the heart of the system. It is a thoroughly robust and reliable heart, not subject to failure. Its functions are manifold and it has made possible the adoption of a working steam temperature for turbines up to the limit which the metals used for construction are able to withstand. This result is a direct consequence of the means afforded by the pump to maintain a temperature, uniform within very narrow limits, in spite of wide variations of load, combustion conditions, &c. The pump is quite simple in construction, consisting of a single impeller, which rotates within a heavy steel housing. Fig. 2 shows a pump in course of erection together with its turbine. The impeller with its shaft is exposed, lying in front of the base plate. The small size of the impeller may be readily seen from this

* Abstract of paper presented at a joint meeting of the Institute of Fuel and the Institution of Mechanical Engineers on November 9th, 1934.

photograph. Fig. 3 shows the complete pump unit. The impeller shaft is fitted with a labyrinth gland. This gland is entirely effective and there is nothing in its construction which has not been well established in normal practice.

Referring to Fig. 3, the labyrinth gland may be seen with the steam channels with which it is provided. If saturated steam from the pump housing were allowed to pass through the gland, some condensation would occur which would cause erosion of the fins of the labyrinth. To obviate this, high-pressure steam drawn from the radiation superheater at a temperature of 770 deg. Fah. enters at A and passes to the gland near the impeller. Part is withdrawn at B at a pressure of about 190 lb. per square inch, and is conducted to the steam inlet of the

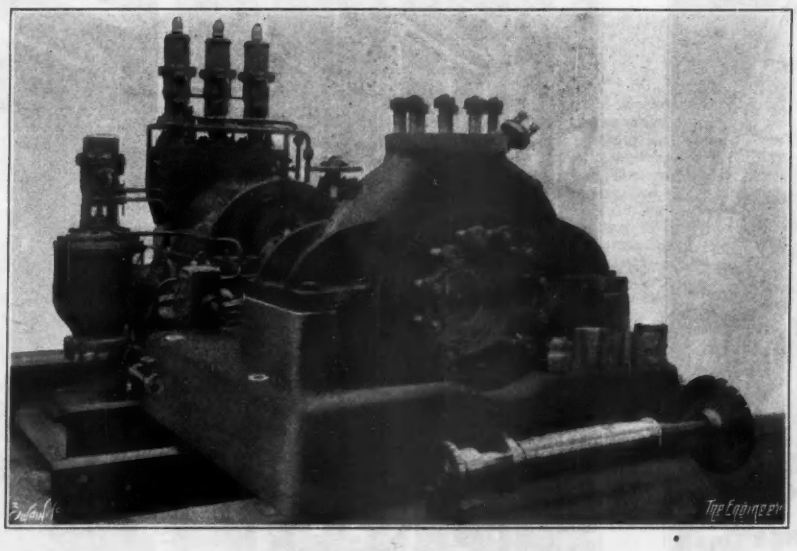


FIG. 2—STEAM PUMP IN COURSE OF ERECTION

turbine driving the pump. The remainder of the steam from the gland escapes at a little above atmospheric pressure, and is utilised for preheating the feed water. As an interesting feature of the design, it may be pointed out that in order to preserve the fine clearances in the labyrinth gland against the influence of expansion, the pump housing is supported on the level of the centre line of the shaft.

One of the incidental functions of the pump, which, nevertheless, has a very definite value, is to remove by centrifugal action any moisture which may be carried over with the saturated steam leaving the evaporating drums. Ports provided at the periphery of the housing collect such moisture, which automatically flows back to the drum, the pressure in the housing being greater

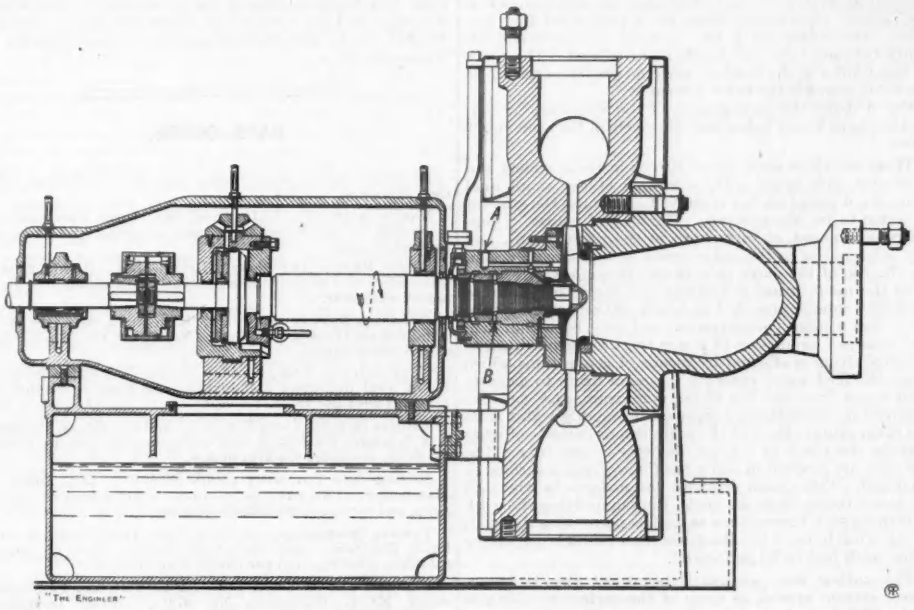


FIG. 3—LONGITUDINAL SECTION OF STEAM PUMP

than that within the drum. The main purpose of the pump, however, is to circulate steam at the desired velocity through the system and by variations in that velocity to maintain a uniform final temperature of steam for delivery to the turbine. The ability of the pump to secure this result by simple speed control may be readily understood when it is appreciated that a given quantity of heat transmitted through the heating surface may be absorbed in a large quantity of steam at a low temperature, or in a smaller quantity at a higher temperature. The pump provides the means for varying the quantity at will, and instantly, so that it is possible to maintain a constant temperature at the expense of a variation in quantity. Variations in demand for total heat must ultimately be met by combustion control. Combustion control is of necessity, owing to the number of factors involved, somewhat low, and the Loeffler boiler, in virtue of the steam-circulating pump, is much more quickly responsive to variations in load than would be possible by combustion control alone. The heat stored up in the metal of the tubes may be made instantly available by an increased velocity of steam, the tubes acting as a heat accumulator which serves to compensate for lag in combustion control. In a water-tube boiler, an increased demand for steam does not result in an increased rate of circulation of the water.

The steam pump, notwithstanding the power required for its operation, is the source of a very real practical economy not fully appreciated when comparing guaranteed test performances of Loeffler and water-tube boiler systems. When testing a water-tube boiler and turbine group, every effort is made to maintain the average steam temperature as closely as possible to that specified, but even then, in the majority of cases, the turbine manufacturers have to claim an allowance for the difference between the actual average temperature and that which was specified. In every-day operation this difference is usually greater, and over a period of a month's operation the allowance for low temperature would be considerable.

Since it is possible with the Loeffler system to operate continuously producing steam at the predetermined temperature, a high steam temperature may be adopted. It is not necessary to assume that under some extraordinary conditions the steam temperature may be higher than that desired. For this reason alone, a steam temperature may be adopted for the Loeffler system which is about 100 deg. Fah. higher than would be considered practicable with the ordinary system. The steam pump therefore effects its own economies, it more than pays for the power absorbed for its operation and for the capital charges which may be allocated to it. Expressed in another way, it may be said that if a device requiring as much power, and costing the same money, could be applied to a water-tube boiler system and succeed equally in maintaining uniformity of steam temperature, such a device would be a welcome extra in all such installations.

The fact that for every pound of feed water supplied to the boiler, about 3 lb. of steam are circulated, might prompt the fear that so much turbulence in the vaporiser drums would result in a large amount of water being carried out of the drums with the steam. Actually, however, this is not the case, and may be readily understood when it is realised that, owing to the high pressure, the volume of the steam bubbles is relatively small, while the even distribution of steam throughout the drum serves to minimise turbulence. In proof of this may be cited an investigation made by Professor E. Josse, of the Technical University, Berlin, at the Caroline power station at Vitcovice. This Loeffler plant, which was installed some years ago, was more liberally provided with drum capacity than would be considered necessary in present-day practice, but the dryness of the steam leaving the drum established how groundless were the fears that water might be carried over. Professor Josse made a number of carefully conducted steam calorimeter tests both on the steam leaving the drum and on that leaving the steam circulating pump. He found that the steam leaving the steam circulating pump had on an average a heat content of 4·5 B.Th.U. per lb. higher than that of saturated steam at the same pressure. This amount of superheating is approximately equivalent to the power absorbed by the pump, which latter would in large part be transformed into heat of compression in the steam. This definitely established that the steam leaving the drum was dry.

The circulating steam pump has a speed range from 2000 to 8000 r.p.m., and is controlled by means of a small hand valve. A revolution counter serves to enable the operator to adjust the speed to meet any known change in load. The relation between the speed of the pump and the load can be reduced to a curve for any given installation, and this relation can be quickly learnt by the operator. For purposes of steam temperature control, the operator can, as occasion may demand, adjust the speed above or below that established on the curve. He will know, however, what the speed should be for normal conditions. In practice it is found that this speed adjustment is so simply effected, and makes such a small demand on the operator's attention, that automatic control, which obviously could be so readily applied, is not regarded as being necessary or desirable.

In the Loeffler system it is possible to adopt drums of less costly construction than is the case with water-tube

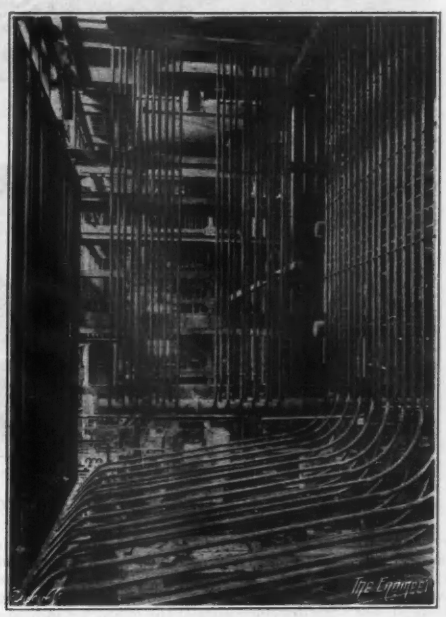


FIG. 4—COMBUSTION CHAMBER

boilers. The shell has not to be perforated for boiler tubes, and therefore the thickness of the wall can be less for a given pressure. The drums being outside the boiler setting may be placed in any convenient position, preferably low down in the boiler-house, in order to minimise the costs of structural supports.

The greater reliability of the Loeffler system is reflected in the concessions which have already been granted in some countries in the regulations applying to feed pumps for steam boilers. The Loeffler boiler is practically independent of a continuous supply of feed water. So long as any water at all remains in the drum, there can be no danger from overheating. In the event of the supply of feed water ceasing entirely, there is sufficient water in the drums to enable the plant to be operated for a period of from seven to ten minutes, and this provides ample time to check the rate of combustion or to put a reserve pump into operation. It is in recognition of this element of safety that the severity of the regulations referred to has been relaxed.

In comparing the capital costs of complete power stations, taking in one case a low or medium pressure steam station, and the other high pressure under Loeffler conditions, so many factors are in favour of the Loeffler system that no additional capital charges need be involved. The reduction in consumption of steam per unit generated, the reduction in fuel to be handled and consumed, the reduced heating surface, the smaller condensers, the lack of necessity for evaporators, the cheaper constructional work owing to reduced space occupied and position of boiler drums, the smaller diameter of steam piping and smaller size of valves, fittings, &c.—these items serve to indicate at least that it is reasonably possible to secure the economical advantages of high pressure and high temperature steam without incurring increased capital charges.

Reference has already been made to the application of Loeffler boilers requiring exhaust steam for heating purposes, and the demand for high-pressure boilers for such purposes is certain to increase, as will appear from the following considerations.

Industrial concerns, such as chemical works, paper factories, and the like, require heat for their processes, both in the form of steam and power. Both may be derived from one source, but the proportion of the demand for each will vary in different factories, and in individual factories the proportion may vary during each day, week, or season. These variations have to be met by provisions

which are well understood, but it is desirable that the proportion of power generated to the exhaust steam available should as nearly as possible meet the average requirements. There is, however, affecting all factories a general tendency towards a change in the proportion in the demand for power and steam. The progressive introduction of labour-saving machinery increases the demand for power, while the advances made in the better utilisation of heat results in a steady decrease in the quantity of steam required per unit of factory output. Thus the steam and electric power plant, when first installed, may provide a relation between the power generated and the heat available in the exhaust steam to conform with the average demand, but with developments of the character indicated more power will be required in proportion to the demand for exhaust steam.

A problem of this character presented itself at the Hoechst Works of the I.G. Dyestuffs Company, and after a most exhaustive investigation it was decided to install three Loeffler boilers, each having a capacity of 70,000 lb. to 100,000 lb. of steam per hour at a pressure of 1800 lb. per square inch and a temperature of 930 deg. Fah. This steam will supply a back-pressure turbine exhausting at a pressure of 225 lb. per square inch into the steam main, which supplies steam at this pressure to the original back-pressure turbines. These turbines exhaust against a back pressure of 55 lb. per square inch for process purposes. By this arrangement, an additional 7000 kW may be obtained without any increase in the production of exhaust steam. In this case the Loeffler boilers are fired by means of travelling grate stokers.

The reasons which determined the choice of Loeffler boilers for the generation of high-pressure steam were twofold. First, the necessity for using 100 per cent. make-up for feed water, and, secondly, the control of temperature which the circulating steam pump of the system afforded for maintaining the maximum steam temperature under all conditions of operation.

The new central power station at Trebovice, Czechoslovakia, was designed and erected after a decision had been reached to generate steam at a high pressure and temperature, and to adopt the Loeffler system for this purpose. The general design and arrangement have been made so that the station in its final form will be able to generate 150,000 kW. The present steam plant consists of three Loeffler boilers, each having a capacity at maximum rating of 160,000 lb. of steam per hour at a pressure of 1900 lb. per square inch and a temperature of 930 deg. Fah. The boilers are fired with coal having a calorific value of approximately 12,600 B.Th.U. per lb. Two Skoda turbines are installed for an output of 21,000 kW each. The turbines are bled in three stages for the purpose of heating the feed water to a temperature of 405 deg. Fah. The steam leaving the first stage of the turbine passes to an intermediate superheater, wherein it is reheated by means of steam from the boiler to a temperature of 645 deg. Fah.

The following guarantees of performance have been given for this plant :—

Per cent of rated capacity	100	..	70	..	40
Kilowatts delivered to consumer	42,000	..	29,450	..	17,010
B.Th.U. per kilowatt ..	13,167	..	12,988	..	14,553

For the operation of auxiliaries a house turbine has been installed to give a maximum of 3500 kW when supplied with steam at 285 lb. pressure per square inch and a temperature of 645 deg. Fah. This steam may normally be supplied from the main turbine, but may also be supplied from one of two low-pressure boilers which form part of the station equipment.

Fig. 5 is an interior view of the Trebovice station showing the three boilers. The steam circulating pump for the central boiler can be seen on the operating floor. Fig. 4 shows the furnace of a Loeffler boiler in course of erection at Trebovice, and illustrates the arrangement of the radiant superheater tubes for a pulverised fuel furnace. The tubes are 2·4in. external diameter and all joints between tube and headers are welded. There are no hand holes in the headers, since no provision has to be made for cleaning the tubes internally.

Fig. 6 shows the arrangement of the secondary or convection superheater tubes, and above them the economiser tubes.

There are three main steam drums in these boilers and a smaller mud drum. The adoption of the small mud drum is not essential, but it serves to minimise the amount of water to be blown down. There is, of course, a considerable amount of turbulence in the main drums, and any solid matter in the water would be kept in suspension. By the use of the extra mud drum, through which water from the main drums constantly but slowly circulates, a quiescent zone is provided in which settlement may take place and a more concentrated mud may be withdrawn. The constant circulation of water from the main drum to the mud drum is effected by means of connections which cause the feed water entering the main drum to aspirate clear water from the top of the mud drum, and water so removed is automatically replaced by muddy water from the main drum. Each of the main drums consists of what may be described as a large diameter forged tube. The flat ends are screwed in and a reinforcing ring is shrunk on each end. This design provides flat surfaces to which all necessary connections are made, thus simplifying the work of making such connections as well as permitting the walls of the drum to be of less thickness than would be necessary if the walls had to be perforated.

The author was permitted to inspect the Trebovice power station as well as some of the earlier installations of Loeffler boilers, and the first impression obtained of the general appearance was that of a normal boiler-house of modern design. Contrary to anticipation, a striking feature of the plant was its simplicity. Obviously, the plant required no exceptional attention, there being that absence of activity among the operatives which is common in modern boiler-houses. At the time of the inspection referred to, two boilers were in operation and the load on the main generator was 15,000 kW. Each boiler was evaporating about 70,000 lb. of steam per hour. In order to demonstrate how readily the boilers could be controlled, the operator was asked to transfer part of the load on one boiler to the other, so as to effect a material change in the operating conditions of each boiler. The speed of one pump was gradually reduced, while that of the other was increased. This was followed by changes in the air and fuel supply to the burners. The boilers quickly responded and at the end of seven minutes the evaporation of one boiler was raised to 110,000 lb. per hour, while that of the other was reduced to 30,000 lb. per hour. The pressure and temperature remained constant throughout these changes.

Following the success which attended the application of the Loeffler system in land practice, it became apparent that it possessed many advantages which would be particularly advantageous in marine practice. After thorough investigation in co-operation with experienced marine engineers, special designs have been completed suitable both for mercantile and naval application. The outstanding advantage of immunity from danger arising from impure feed water has particular value for sea-going vessels, while the facilities offered for a favourable disposition of weight and for economy of space and fuel constitute benefits which must materially improve the economics of marine practice.

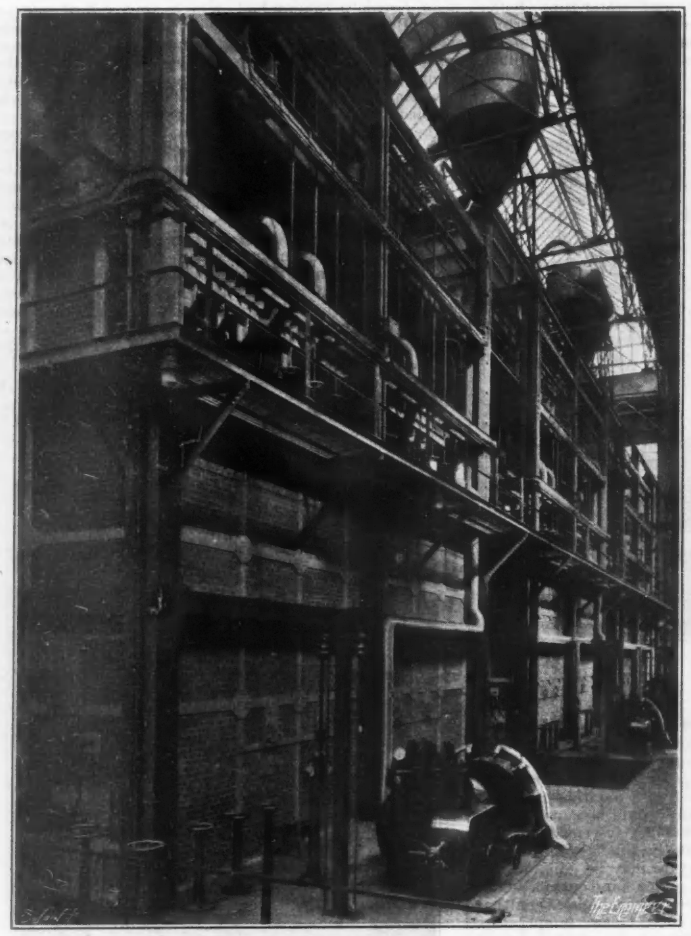


FIG. 5—THREE LOEFFLER BOILERS, TREBOVICE POWER STATION

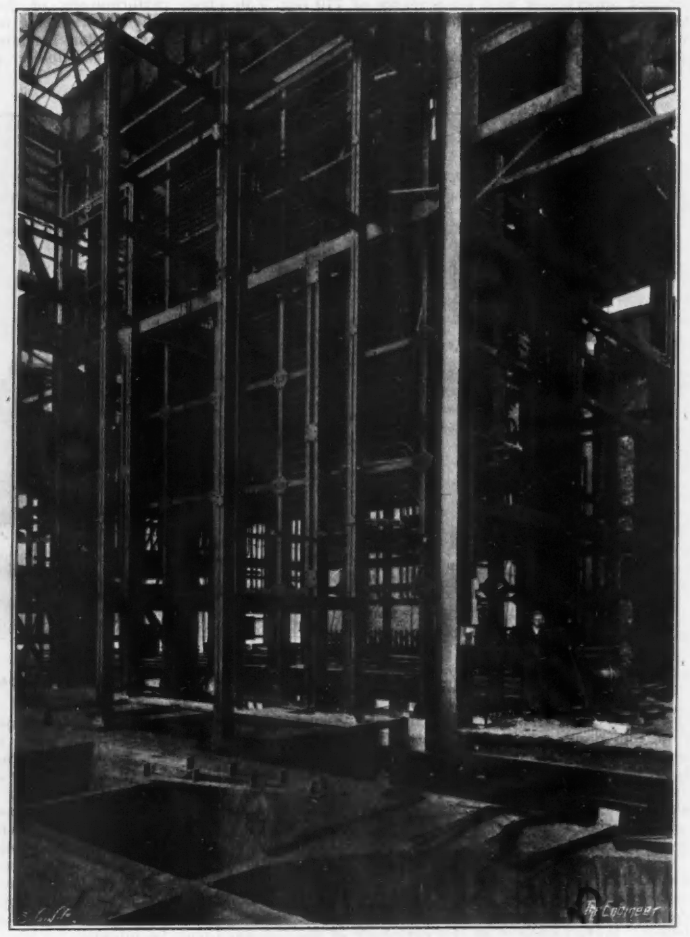


FIG. 6—SECONDARY SUPERHEATER AND ECONOMISER UNDER ERECTION

CATALOGUES.

RUSTON AND HORNSBY, Ltd., Lincoln.—Publication 6736 on "Economic" boilers.

MARKHAM AND CO., Ltd., Broad Oak Works, Chesterfield.—A booklet on the Stead and Clarke overwind and overspeed prevention gear.

DAVID BROWN AND SONS (HUDD.), Ltd., Huddersfield.—Particulars of a multiple independently adjustable feed mechanical lubricator.

ANDERSON SUTTON AND CO., 42, High-street, Hampton Wick, Kingston-on-Thames.—Catalogue No. 12 on the firm's rotary piston steam engine.

GENT AND CO., Ltd., Faraday Works, Leicester.—Book 6E, liquid level indicators and alarms, and book 5, Section 2G, electric turret and bracket clocks.

THOMAS ROBINSON AND SON, Ltd., Railway Works, Rochdale.—A brochure illustrating and describing the various type of moulding machines the firm makes.

RENOLD AND COVENTRY CHAIN COMPANY, Ltd., Didsbury, Manchester.—1934 price list of products for industrial applications, and catalogue of stock chain drives.

THOMAS SUMMERSON AND SONS, Ltd., Darlington.—A catalogue illustrating and describing various types of railway switches, crossings, and permanent way fittings.

BABCOCK AND WILCOX, Ltd., Babcock House, Farringdon-street, E.C.4.—Publication No. 971C, "Water Treatment: The Care of Modern Steam Generating Plant from the Water Side."

CALORIZING CORPN. OF GREAT BRITAIN, Ltd., 32, Farringdon-street, E.C.4.—Publications No. 1148 on the calorising process; and No. 1149 giving particulars of "Calmet" heat-resisting alloy steel.

M.C.L. AND REPETITION, Ltd., Pool-lane, Langley, Birmingham.—A 32-page booklet containing many useful tables and illustrating some of the firm's products in amusing cartoons of a military character.

EDGAR ALLEN AND CO., Ltd., Imperial Steel Works, Sheffield.—A booklet on mining drill steels dealing in detail with the manufacture, structure, and advantages and disadvantages of various types of drill steel.

STREAM LINE FILTER COMPANY, Ltd., Hele Shaw Works, Ingate-place, S.W.8.—Brochures No. 102, entitled "Oil Purification and the Diesel Engine User"; No. 101, "Oil Purification and the Modern Transport Engineer."

GENERAL ELECTRIC COMPANY Ltd. Magnet House, Kingsway, W.C.2.—Two new publications, HO. 7024 and HO. 7026, dealing with G.E.C. electric furnaces generally and illustrating a large number of typical installations, and with the Grunewald furnace for the bright annealing of metals.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The Steel Export Markets.

Interest in the export markets seems to be centred upon the position in India, where a keen fight has developed between the British and Continental steel makers. The recent action of the British steel makers in revising their prices and extras list for India brought them a considerable volume of trade, but it was not long before the prices for Continental steel were reduced to meet the new British quotations. No movement was made by the Cartel to alter its official prices, but merchants were able to quote much lower terms. During the past few days, however, rumours have been current that the controlling body on the Continent has decided to quote the same prices to Indian buyers as for the British market, and on important orders to quote especially low figures. If this change is made officially it will bring the price of Continental steel bars for India down from £4 19s. to £4 10s. f.o.b., of joists from £4 13s. 3d. to £4 11s. 6d., and of plates, ½in., from £7 4s. 6d. to £5 12s. 6d. In some cases it is known that prices approximating these have been quoted by Continental sellers, and as they work out at lower than the British prices, even when the high Indian duties are taken into account, the British works have lost a fair amount of business. The Continental steel makers are also reported to be worried at the small amount of business they have taken from Japan. It is suspected that the Japanese, owing to the resentment they felt at the measures taken by the Cartel for dealing with their orders at a time when it thought that they would be obliged to go to that body for steel, have placed nearly all their requirements outside the countries under its control. The position of the German works is still causing some perturbation amongst the other Continental steel makers, as a considerable volume of orders for steel is said to be reaching Germany as a result of barter transactions which do not pass through the Cartel organisation.

The Pig Iron Market.

The opening days of November brought a change for the better in the pig iron market. Deliveries against contracts have been well maintained since the end of the summer, but new business in the latter part of October was rather listless. This month the demand has been more active, and some consumers who had delayed placing contracts have bought forward over an extended period. The situation on the North-East Coast is particularly good, and there is again talk of increasing the production in this district. With only three furnaces making foundry iron it is not surprising that the production is insufficient to keep pace with the demand. The stocks, which have been only moderate for some months, have been further reduced lately through the makers taking iron to supplement their outputs. The requirements of the light castings industry in Scotland and on this coast, although not so heavy as a few weeks ago, are considerable, and provide a steady outlet for Cleveland iron. Local consumption, also, is on a good scale, and export business shows a tendency to increase; but in this direction the producers are inclined to adopt a cautious attitude owing to the uncertain financial conditions in many overseas countries. The Midland market, also, has shown more activity since the month opened, and deliveries to the light castings makers have increased. This indicates that the decline in operations in this industry was only of a temporary character. In this district substantial stocks are said to exist at several of the furnaces, although they are not sufficient to cause anxiety to the producers. There is, therefore, no difficulty about deliveries, and this has no doubt influenced consumers in adopting a policy of buying only for their immediate needs. The call for Midland forge iron fluctuates within narrow limits, but at the moment it seems to be gathering strength. Buying by the motor trades lately has improved. Low phosphorus irons are quoted at 85s. to 87s. 6d., and medium phosphorus at 72s. 6d. to 80s. Conditions in the Scottish pig iron market have not materially altered. Export business has been light, but the home trade has been active, although there are few signs of the demand increasing. Business in basic iron in all districts continues on a satisfactory scale, but recently some of the steel works have shown a disinclination to increase their commitments. The demand for hematite has been brisk, and heavy deliveries continue to be made to the consuming works in Lancashire and the Midlands, whilst users in South Wales have taken good supplies.

The North-East Coast and Yorkshire.

Although the steel works on the North-East Coast are not operating at capacity, they are producing heavy quantities of manufactured steel. Recently some anxiety was felt at the scarcity of new business, but this phase seems to have passed and the steel makers report that new orders are coming to hand at a more satisfactory rate. One of the most favourable features of the position is the improvement in the demand for shipbuilding steel as a result of orders which have been placed on the Tyne. Nevertheless, the works are laid out to deal with a much greater flow of business than they have experienced for a long time. The demand for semi-finished steel, chiefly in the form of billets, is improving, and there is less competition experienced from importers of Continental material, who may possibly be getting tired of accepting the low prices necessary to secure orders in this country. The mills producing railway material have completed a number of contracts lately, and it is anticipated that the railway companies' programmes for next year will provide them with a large volume of work. Business in sheets is only moderately good, and depends to a large extent upon the home demand. Export trade shows little expansion; a certain amount of Indian business has reached the works lately, and orders have been secured also from South American markets. The Yorkshire steel industry, on the whole has gained rather than lost ground since the end of October. In Sheffield the works are well employed, and business in special steels, in particular, is at a high level. Good orders for railway material, including tires and axles, have come to hand and have placed this section of the industry in a strong position. The demand for stainless steels has kept up well, and production has been assisted by some heavy contracts for stainless steel studs to mark pedestrian road crossings. Some of the makers anticipate that the manufacture of these studs will provide a new and valuable outlet for their steel.

Scotland and the North.

The Scottish steel works are enjoying a spell of great activity which it seems certain will be maintained until the end of the year and probably well into 1935. The shipyards, however, are completing tonnage much more quickly than new orders are being received, but there are well-founded hopes that new contracts for ships will be placed more freely during the next few months. Vessels totalling more than 170,000 tons have been launched on the Clyde over the last three months, whilst the new orders placed have made a poor showing. There is a good demand for structural steel, and although some of the constructional engineers are less busy than others, generally speaking the situation in this industry is satisfactory. The works making railway stock are well employed, and are anticipating receiving fresh orders in the not distant future. Most of the Scottish sheet works are maintaining a steady rate of production at a little over 50 per cent. of capacity, but the greater part of the work they are engaged upon is in fulfilment of contracts placed early in the autumn, and the amount of new business coming forward is disappointing. Much irregularity in working exists amongst the re-rollers, and it is from this branch of the industry that complaints of the imports of Continental material are the loudest. The quotation for small steel bars is held at £8 12s., less 2s. 6d. rebate, whilst the export price is nominally £7 10s., although less than this is accepted; but even so, competition from abroad limits the amount of export business which can be secured. In the Lancashire market the recent burst of activity has died down, but specifications are still reaching the steel works at a steady rate. The structural engineers are fairly busy, but many of them have covered their requirements for a time, and are not showing much interest in the market for sections and bars, although they are taking good deliveries. The contract for the extension of the Manchester Town Hall, which will require about 5000 tons of steel, has been taken by a Manchester firm of constructional engineers, and all the steel is to be ordered from works in Lancashire. Lately there has been a rather better demand for boiler plates, which has been a depressed section of the market for some time. Business in bright bars and special steels seems to be expanding again after a short lull.

The Midlands and South Wales.

Rather contradictory features have developed in the Midland iron and steel markets. The demand for steel for general purposes has become quieter, but the departments dealing with the more specialised steel descriptions have developed fresh activity. The constructional engineers are not now taking such large quantities of joists and sections as they were even a fortnight ago; but it seems to be generally agreed that this is only a temporary restriction, and that there is a considerable amount of work from this branch of the engineering trades in sight. The re-rollers are moderately busy, but a good proportion of the business in small bars and strip has been taken lately by firms outside the Association. The associated works quote £8 12s. for small bars, less a rebate of 2s. 6d. under certain conditions, against the outside works' quotation of £7 12s. 6d. to £7 15s. For strip the Association price is £9 7s., whilst the unassociated works quote several shillings less. There is still a certain amount of competition from the Continent, but some of the Continental firms have filled their quota for some time to come, and this has lessened the quantities on offer. Quotations, however, work out at £7 1s. for Continental merchant bars, d/d and including duty, and £7 10s. to £8 12s. for strip. The Midland plate makers are not finding the situation satisfactory. The demand for the thick gauges is distinctly poor, and it cannot be considered more than moderate for the thinner sizes. In the case of boiler plates business has been light, and there does not seem at the moment to be any likelihood of an improvement. In the sheet department orders relate chiefly to medium thickness black sheets, and business in the thin gauges remains disappointing. It is in special strip, bright drawn steel, and special steels that the market is most active. The situation in South Wales is encouraging, and most departments of the trade there are moderately active. Business in tinplates is maintained, although competition from Italian sources is reported in South American markets. Important orders have been placed by Canadian consumers for delivery over a period of years, the quantity to be shipped next year totalling 1,250,000 boxes. The sheet works would like more business in the thinner gauges, but the export demand for this description has been poor for some time.

Current Business.

An Admiralty contract for rail and crane tracks with ordinary and special switches and crossings for the Singapore naval base, amounting to about £20,000, has been awarded to Thomas Summerson and Sons, Ltd., of Darlington. Blackstone and Co., Ltd., of Stamford, have secured two export orders comprising seventy-nine cold-starting crude oil horizontal type engines, and the usual incidental auxiliary plant and spares. They have also received a considerable influx of orders lately on home and overseas account. An order for a motor ship of 9000 tons has been placed with William Doxford and Sons, of Sunderland. Orders for two fast trawlers have been placed with Smiths Dock Company, Ltd., of South-bank-on-Tees, by a Grimsby firm. A public works scheme costing £262,500 has been approved by the Denbighshire County Council, a considerable proportion of which will be spent on new roads. The Bath Royal Mineral Water Hospital is to spend £30,000 in building improvements. It is reported that the building and renewal programmes of the British railways for 1935 will involve an expenditure of about 20 million pounds. The Metropolitan Water Board has decided to construct a new reservoir in the Lea Valley at an estimated cost of £950,000. The Department of Overseas Trade announces that the following contracts are open for tender:—Egyptian Ministry of Public Works: One asphalt sprayer, capacity 800 to 1000 gallons (Cairo, December 12th); one D.C. generator, 115 volts, 300 ampères, compound-wound, to give constant voltage at all loads, to be driven at 260 r.p.m.; one small switchboard with voltmeter, ammeter, switch, fuse holders, automatic switch; one high-pressure pump, complete, diameters of suction and delivery 10in., to be fitted to 100 H.P. semi-Diesel engine, 260 r.p.m., suction head 6 m., delivery head 35 m.; one travelling crane, 5 tons capacity, span 11·50 m., to be fitted in an engine-room, 12 m. by 15·5 m., height of chain to be 7 m., complete rails, girders, and brake (Cairo, December 17th). Argentine State Oilfields Department: Steel cables for drilling plant (Buenos Aires, December 11th); New Zealand Public Works Department: Supply of 50-kV outdoor switchgear for extensions at Henderson sub-station (Wellington, February 19th); South African Railways and Harbours: One 5-ton electrically-driven overhead travelling crane (Johannesburg, January 7th).

Copper and Tin.

The electrolytic copper market has lost the confident tone of a week or ten days ago, when it was generally assumed that the producers would reach an agreement upon curtailing production. Negotiations are still proceeding on this point, but so far no announcement has been issued as to the progress made. Business in copper has fluctuated somewhat, but financial conditions in Europe have been against any important movement. Continental consumers are said to be running on short stocks, and business with Germany is out of the question in the conditions existing in that country. The market was at one time hopeful that the Anglo-German agreement with regard to trade debts might lead to further purchases, but apparently the German Government is maintaining a tight hand upon transactions in this metal, and, in fact, there is some talk of copper being re-exported from Germany in order to provide funds for the purchase of ores for the German smelters. In America the position does not improve, and the nature of the demand can be judged from the fact that the primary producers have agreed to extend the preference in sales which they give to secondary and customs smelters over the month of November. Rather more business has been transacted on the London standard market recently, and speculative interest seems to be broadening. There has not been so much electrolytic copper put into standard warehouse of late, but stocks still show a tendency to increase. . . . The tin market has had a lethargic appearance and the demand for industrial purposes has been poor. Whenever prices have shown an inclination to drop below £228 10s. fresh support has been forthcoming—it is assumed from the Pool. Buying by Continental consumers has been confined to a few odd parcels and American business has been almost negligible. Interest is centred upon the meeting of the International Tin Committee next week, and it is suggested that a reduction in the quotas for the first quarter of 1935 may be decided upon. This would arouse protest from some producers, but the impression seems to prevail that unless some action is taken stocks of tin may become unwieldy.

Lead and Spelter.

The lead market has been uninteresting for the past week or two, and prices have moved within narrow limits. The demand from consumers shows signs of declining; but this is not surprising, since buying by users in this country has been upon a large scale for the greater part of this year. The recent slight improvement noticeable in the demand on the Continent has faded away and the financial situation in some of the most important consuming countries does not encourage hopes of any great increase in their lead requirements. The short supply of Empire lead available for the British market continues to arouse comment. It is not easy to get lead for arrival before the end of January or February now, and premiums have strengthened from 20s. to 22s. 6d. for spot metal and 12s. 6d. to 15s. for forward. . . . Conditions in the spelter market have not materially improved, and prices have shown a tendency to recede. The market is still disturbed as to the position which will develop as a result of the increased production in Germany through the starting up of the Magdeburg smelter. It is feared that this will release spelter for export to this country which would otherwise have been consumed in Germany. Reports of dissensions between the members of the International Spelter Cartel have also had an adverse effect upon sentiment. In any case, the Cartel agreement will have to come up for renewal at the end of this year, and it is not surprising that reports are current that notices of withdrawal have been given. This, however, may be merely a move on the part of particular interests to emphasise claims they have made. A feature of the London market is the scarcity of Empire brands. It is said that no metal of this description will be available until early next year. The premium on prompt duty-free metal is 27s. 6d. to 30s., and for January-February arrival 15s. to £1.

Current Prices for Metals and Fuels.

Makers' official home trade prices, per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.: plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home. (*D/d Teesside Area*) £ s. d.	Export. £ s. d.
N.E. Coast—		
Hematite Mixed Nos.	3 8 6	3 0 0
No. 1	3 9 0	3 1 0
Cleveland— (*D/d Teesside Area*)		
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/– rebate*)	3 7 6	—
Midlands—		
Staffs.— (*Delivered to Black Country Station*)		
North Staffs. Foundry	3 11 0	—
„ „ Forge	3 6 6	—
Basic (*Less 5/– rebate*)	3 12 6	—
Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
Scotland—		
Hematite, f.o.t. furnaces	3 11 0	—
No. 1 Foundry, ditto	3 12 6	—
No. 3 Foundry, ditto	3 10 0	—
Basic, d/d (*Less 5/– rebate*)	3 7 6	—
N.W. Coast—		
Hematite Mixed Nos.	3 12 6 d/d Glasgow 4 0 6 „ Sheffield 4 5 6 „ Birmingham	

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Lancs.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. Yorks.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
Midlands—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	7 5 0 to 7 15 0	—
Scotland—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. Coast—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

	Home. £ s. d.	Export. £ s. d.
London and the South—		
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 0	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	—
Flats, 5in. and under	8 14 6	7 2 6
Plates, ¾in. (basis)	9 0 0	7 15 0
„ ⅞in.	9 5 0	8 0 0
„ 1in.	9 10 0	8 5 0
„ 1⅛in.	9 15 0	8 10 0
„ 1¼in.	9 10 0	8 5 0
North-East Coast—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ¾in.	8 15 0	7 15 0
„ ⅞in.	9 0 0	8 0 0
„ 1in.	9 5 0	8 5 0
„ 1⅛in.	9 10 0	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates, ¾in.	8 5 0 .. 7 15 0 to	8 2 6
Midlands, and Leeds and District—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 17 6	7 15 0
„ ⅞in.	9 2 6	8 0 0
„ 1in.	9 7 6	8 5 0
„ 1⅛in.	9 12 6	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates, ¾in.	8 5 0 .. 7 15 0 to	8 2 6

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
Glasgow and District—		
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 15 0	7 15 0
„ ⅞in.	9 0 0	8 0 0
„ 1in.	9 5 0	8 5 0
„ 1⅛in.	9 10 0	8 10 0
„ 1¼in.	9 5 0	8 5 0
Boiler Plates	8 5 0 .. 7 15 0 to	8 2 6
South Wales Area—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¾in. (basis)	8 17 6	7 15 0
„ ⅞in.	9 2 6	8 0 0
„ 1in.	9 7 6	8 5 0
„ 1⅛in.	9 12 6	8 10 0
„ 1¼in.	9 10 0	8 5 0

Ireland—	Belfast. £ s. d.	Rest of Ireland. £ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¾in. (basis)	9 0 0	9 2 6
„ ⅞in.	9 5 0	9 7 6
„ 1in.	9 10 0	9 12 6
„ 1⅛in.	9 15 0	9 17 6
„ 1¼in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

Sheets.	Home. £ s. d.	Export. £ s. d.
10-G. to 13-G., f.o.r.	9 0 0	8 15 0
14-G. to 20-G., d/d	10 5 0	9 0 0
21-G. to 24-G., d/d	10 10 0	9 5 0
25-G. to 27-G., d/d	11 2 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton and 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £16 12s. 6d., c.i.f. duty paid India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel ports, 18/2.
Tin-plate Bars, d/d South Wales Works, £5 7s. 6d.

Billets.	£ s. d.
Basic, Soft (0·25% to 0·41% C.)	6 0 0
„ Medium (0·42% to 0·60% C.)	6 17 6
„ Hard (0·61% to 0·85% C.)	7 7 6
„ „ (0·86% to 0·99% C.)	8 7 6
„ „ (1% C. and up)	8 17 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 tons	5 15 0
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/–
„ „ 6 p.c. to 8 p.c.	£21 12 6	7/–
„ „ 8 p.c. to 10 p.c.	£21 12 6	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£35 0 0	11/–
„ „ „ 1 p.c. carbon	£38 15 0	12/–
„ „ „ 0·70 p.c. carbon	£42 0 0	12/6
„ „ „ carbon free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 5 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£13 0 0 scale 5/– p.u.	
„ „ 75 p.c.	£18 7 6 scale 6/– p.u.	
„ Vanadium	12/8 per lb.	
„ Molybdenum	5/6 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Ferro Cobalt	5/3d. per lb.	

NON-FERROUS METALS.

Official Prices, November 14th.

Copper—		
Cash	£27 10 0 to £27 12 6	
Three months	£27 17 6 to £27 18 9	
Electrolytic	£30 15 0 to £31 0 0	
Best Selected Ingots, d/d Birmingham	£31 0 0	
Sheets, Hot Rolled	£58 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	9½d.	9½d.
„ Brazed (basis)	9½d.	9½d.
Brass—		
Ingots, 70/30, d/d Birmingham	£27 0 0 to £29 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	8¾d.	8¾d.
„ Brazed	10¾d.	10¾d.
Tin—		
Cash	£228 5 0 to £228 10 0	
Three months	£228 12 6 to £228 15 0	
Lead	£10 6 3 to £10 12 6	
Spelter	£11 17 6 to £12 3 9	
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

	Export.
Lanarkshire—	
(f.o.b. Grangemouth)—Navigation Unscreened	13/–
„ Glasgow—Ell	15/– to 15/6
„ „ Splint	16/6
Ayrshire—	
(f.o.b. Ports)—Steam	13/–
Fifeshire—	
(f.o.b. Methil or Burntisland)—Prime Steam	13/– to 13/3
Unscreened Navigation	12/6 to 13/–
Lothians—	
(f.o.b. Leith)—Hartley Prime	12/6 to 13/–
Secondary Steam	12/– to 12/3

ENGLAND.

Yorkshire, Manchester—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	13/– to 17/6
Northumberland, Newcastle—	
Blyth Best	14/3 to 14/6
„ Second	13/–
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 13/6
Durham—	
Best Gas	14/8
Foundry Coke	18/6 to 22/6

Sheffield	Inland.
Best Hand-picked Branch	24/– to 26/–
South Yorkshire Best	21/– to 23/–
South Yorkshire Seconds	17/6 to 19/–
Rough Slacks	8/– to 9/–
Nutty Slacks	7/– to 8/6

SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Admiralty Large	19/6
Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Best Bunker Smalls	13/6 to 14/–
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 26/–
Foundry Coke	24/– to 37/6
Furnace Coke	19/– to 21/6
Patent Fuel	21/–
Swansea—	
Anthracite Coals:	
Best Large	37/6 to 40/–
Machine-made Cobbles	33/6 to 46/6
Nuts	34/– to 45/–
Beans	26/6 to 34/–
Peas	18/6 to 22/6
Rubbly Culm	10/– to 11/–
Steam Coals:	
Large	24/– to 28/–

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

Manchester prices ½d. per gallon extra.

French Engineering Notes.

(From our own Correspondent in Paris.)

The Trade Policy.

ALL industrial interests are waiting with anxiety to see what policy Monsieur P. E. Flandin will adopt in order to bring about some economic recovery, and it is probable that never before has the industrial fate of this country been placed so unreservedly in the hands of a President of the Council, whose skill in dealing with economical problems is generally acknowledged. The situation is so precarious and difficult that no solution is deemed possible except by a man possessing authority to lay the groundwork of a general plan of recovery and to put it into execution. Monsieur Flandin has stated that his first aim will be to do what is possible to improve the conditions of national economy, and he has given a fairly clear idea of what that policy will be by affirming his distrust of anything implying a State control of industry. Having failed, in the present abnormal circumstances, to extricate themselves from an unparalleled depression by their own efforts, industrialists can now only look to the State for aid, and it is difficult to conjecture in what way this will be rendered, for the State has attempted nearly everything in the way of protection, so that the only remedy left would appear to be the initiation of some policy to increase national consumption. Monsieur Flandin has, at times, made suggestions of this kind. Nevertheless, it does not seem probable that there will be any appreciable slackening of the protective system, except so far as it may benefit home industries, and there are national industries which can only be saved from extinction by means of facilities for foreign trade exchanges. In his capacity of Minister of Public Works in a former Government, Monsieur Flandin explained that railway electrification would only be carried out where it would save the country from importing coal. Nothing would be undertaken that would be detrimental to the home colliery industry. If the present Government should last long enough to carry out plans, there may be a revival of confidence favourable to some industrial recovery, which will necessarily involve the provision of more facilities for foreign trade.

Railway Improvements.

The first undertakings to be put in hand under the public works relief programme are those rendered necessary by the diversion of the Normandy express services from the Gare Saint-Lazare to the Gare Montparnasse, which will deal with the entire long-distance express traffic on the State system. The idea of enlarging the Gare Saint-Lazare by means of platforms below those already existing in order to provide a separation of the main line and growing suburban traffic had to be abandoned. The real reason for closing the terminus to fast main line traffic was the impossibility of further widening the approach to the station. The proposal to reconstruct the Gare Montparnasse on an adjacent site has had to be postponed on account of the cost, and the work now put in hand comprises the construction of a goods station covering a considerable area between the terminus and the site of the fortifications behind it. A reinforced concrete shed in the yard will have a length of 200 m. The lines between Clamart and Versailles will be doubled in order to allow of the existing road being used exclusively for express trains. This will entail a good deal of bridgework, as will also the suppression of level crossings. The work further comprises an extension of the automatic block system with luminous signals showing red for danger, yellow for caution, and green for a clear line. The credit allocated for the work is 550 million francs, and the undertaking has been put in hand at once, because the Gare des Invalides and its extensive goods yard must be transferred to the Paris Municipality in time to lay them out for the Paris Exhibition of 1937.

Engineers' Training.

In view of the large number of engineers who are out of employment, the State schools have been reducing the number of applicants for admission, but apparently there is no longer the same necessity to restrict entries as formerly, since other important institutions seek, for the first time, to attract students by giving publicity to the success of engineers holding their diplomas. The fact of so many engineers being unable to find occupation has discouraged parents from regarding the profession as offering a sure and remunerative career for their sons. So long as the country was engaged upon a vast plan of national industrial development, the possession of a first-class degree was practically a guarantee of permanent and lucrative employment, and the number of engineers increased in a way commensurate with the openings offered to them during a period of exceptional industrial activity. There can be no illusion now about a possible return to those conditions. The economic situation has changed, and there will evolve out of the present slump a reorganised industry, less affected by abnormal influences, that will offer better opportunities to engineers because their number will be automatically reduced by the elimination of doubtful degrees, and their professional value will be increased by the generally higher standard of training now required of those taking degrees. A census of former students of State schools and universities and institutions at present engaged in various occupations tends to indicate the value of a training that will widen the engineer's qualifications. The census shows that the occupations cover many branches of trade and industry, often without the necessity of technical attainments. There is no idea of checking specialisation, but it is urged that, in many cases, the engineer should be prepared for occupations outside his specialised sphere, and particular stress is laid upon the importance of culture and moral qualities that will fit him for any position of responsibility. The aim of schools and institutions is to raise the level of qualification for first-class degrees as nearly as possible to that of the Ecole Centrale, for example, which gives a highly cultural character to its training. While widening their qualifications, it is intended to raise the general standing of French engineers at home and abroad.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

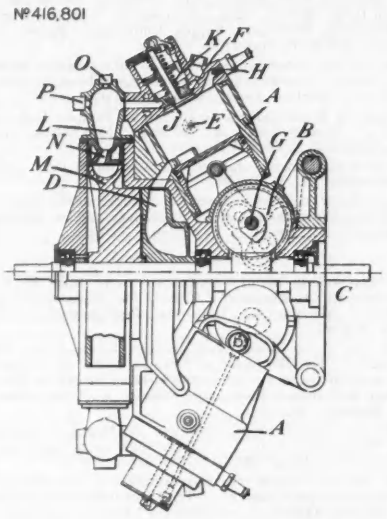
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

TURBINE MACHINERY.

416,801. April 6th, 1933.—INTERNAL COMBUSTION TURBINES, C. E. M. March, Penny Oak, Fulmer-road, Gerrard's Cross, Bucks.

In this turbine the charge is compressed in the pumps A A, which are driven by the linkage B and worm gear C from the main shaft. Air is blown into the cylinders by the fan D, and

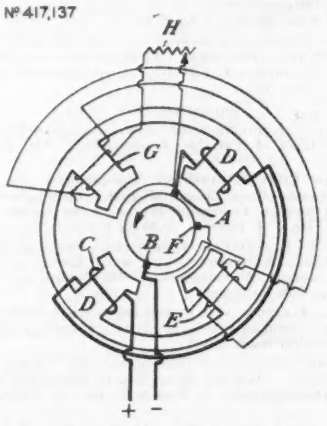


fuel is admitted at E. Towards the end of the compression stroke the poppet valve F is opened by the cam G and the charge ignited by the plug H. The valve J is opened against the pressure of the spring K, and the burning charge escapes into the chamber L and drives the turbine M by the nozzles N. Additional fuel and steam may be added at O and P.—*September 21st*, 1934.

DYNAMOS AND MOTORS.

417,137. April 24th, 1933.—DYNAMO-ELECTRIC MACHINES, Harold Dakin Wheeler and Paul Alphonse Hubert Mossay, both of Gothic Works, Norwich.

This invention, which is shown applied to a shunt-wound machine, is particularly suitable for application to arc welding generators and to generators intended for parallel running which are subject to wide speed variations, and are generally controlled by diverters, which are expensive and clumsy and do not lend themselves to fine adjustments. It is also suitable for application to multiple-speed series motors for driving fans or the like, to enable the different speeds to be obtained without the use of tapped series windings or diverters. The machine diagrammatically illustrated may be an arc welding generator. A and B are the main brushes of the machine. C is the winding of the interpoles or auxiliary poles D. E is the usual shunt winding. An auxiliary brush F is situated electrically, approxi-

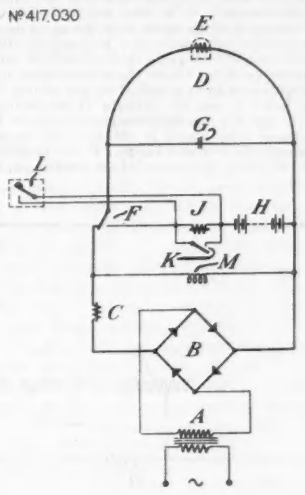


mately midway between one main pole and one interpole. An auxiliary shunt winding G is connected between the auxiliary brush F and the adjacent main brush A. The auxiliary shunt winding G is provided on the main poles and is excited by the voltage generated in the armature turns lying between the main and auxiliary brushes A and F to which the auxiliary shunt winding is connected. These armature turns cut part of the interpole flux, and the voltage is approximately proportional to the armature current. A series winding effect is thereby produced by the auxiliary shunt winding G. Any suitable means, such as a rheostat H, connected in series with the auxiliary shunt winding G may be provided to regulate the excitation of the winding, the regulating means being required to deal only with comparatively small currents. The provision of the auxiliary shunt winding G according to the invention permits the external characteristics of the machine to which it is applied to be varied as desired.—*September 28th*, 1934.

ELECTRICAL APPLIANCES.

417,030. February 26th, 1934.—ALARM DEVICES FOR INDICATING CURRENT FAILURE IN ELECTRIC SUPPLY SYSTEMS, Elektrozeit Aktiengesellschaft, of Mainzerlandstrasse 136–140, Frankfurt-a-Main, Germany.

This invention relates to electric circuit arrangements in which an alarm device is provided for indicating failure of the current. An example of a system in accordance with the invention is illustrated in the accompanying drawing, in which the normal supply of current is obtained from A.C. mains. With D.C. mains the only difference is in the mains connection device. The current flows from the secondary of the transformer A to the rectifier B, whence it flows through the relay C and the circuit D, which includes an alarm E, back to the rectifier. The alarm is of such a nature that it will operate when deprived of current. If the mains voltage fails or drops below a predetermined value the relay C releases and throws its contact F. The condenser G connected in parallel with the circuit D discharges through the alarm E as soon as the voltage drops and before the switch F is thrown. Thus the current is maintained in the circuit D and the alarm E is prevented from

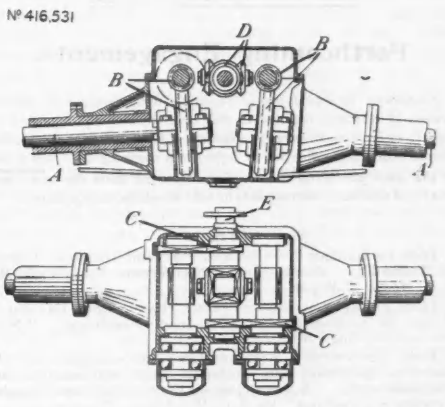


operating. The contact F connects the reserve battery H and the circuit D. An alarm relay J in series with the circuits and the battery causes an indicating signal to be given—a buzz, for example—by means of the short circuit contact K so as to indicate that the circuit has been switched over. This signal can be stopped by means of the stopping key L. When the mains voltage is restored a current flows through the resistance M and when the voltage has risen to its normal value the relay C is caused to operate again. The contact C is thus switched over and the battery is switched out again. The capacity of the condenser G is preferably large and an electrolytic condenser is preferably used, as a large capacity can thus be obtained from a condenser which takes up only a relatively small space. —*September 26th*, 1934.

MOTOR CARS AND ROAD TRAFFIC.

416,531. July 20th, 1933.—BACK AXLES, J. I. Thornycroft and Co., Ltd., Smith-square, Westminster, and Sir J. E. Thornycroft.

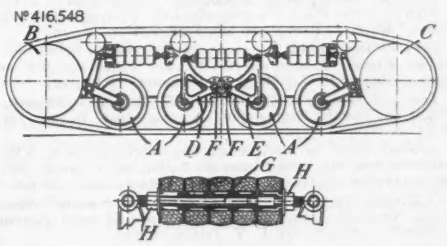
If a motor vehicle is provided with twin tires on the rear wheels there is a tendency for the inner tires to be overloaded



on account of the camber of the road surface. The inventor therefore also cambers the back axle, to the extent of about 3 deg. from the horizontal, and each of the live axles A A is driven by a worm and wheel gear B, through the toothed gearing C C from the differential D on the propeller shaft E.—*September 17th*, 1934.

416,548. January 15th, 1934.—ENDLESS TRACK VEHICLES, L. Renault, 8, Avenue Emile Zola, à Billancourt, Seine, France.

This invention relates to endless track vehicles of the kind in which the load-supporting rollers are mounted in a resilient manner by the use of rubber blocks and aims at providing arrangements for mounting the supporting rollers, whereby the



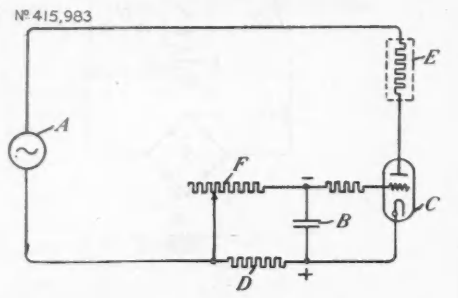
resiliency of the mounting may be adjusted according to circumstances, as, for instance, to the nature of the ground, the load of the vehicle or the wearing of the rubber block. The endless track requires, in the usual manner, four load-supporting rollers A, suitably distributed between the idle pulley B and the control pulley C. The two central rollers are mounted at the extremities of levers D E, pivoted on the chassis at F F. The opposite ends of the bell crank levers are connected

with telescopic rods G—see detail sketch—provided with rubber buffers, the compression of which can be determined by the nuts H H.—*September 17th*, 1934.

MISCELLANEOUS.

415,983. April 24th, 1934.—Intermittent Current Generators, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2.

In many industrial applications there arises a need for an intermittent current of a frequency variable within wide limits. It is an object of this invention to provide a new and improved intermittent current generator which is particularly simple, economical, and reliable in operation. In explaining the operation of the apparatus, it is assumed that the alternating-current source A has just been energised, and that the capacitor B is completely discharged. It is also assumed that when the potential of the grid of the valve C is the same as that of its cathode, the valve is fully conductive, although it will be understood that various grid biases may be employed for valves having other grid characteristics. Under these conditions, the first half cycle of alternating current supplied by the source A will flow through the valve C and the resistor D energising the load device E. The current flowing through the resistor D will produce a resistance drop which is effective to charge the condenser B through the variable resistor F, the polarity being as indicated in the drawing. Under these conditions, the grid of



the valve becomes highly negative, and is effective to prevent the flow of current in the valve during the succeeding positive half-cycle of alternating current supplied by the source. The charge on the capacitor B is gradually dissipated in the discharge circuit including the variable resistor F and the resistor D, and, when the condenser B becomes sufficiently discharged, the potential of the grid falls below the critical grid potential of the valve and it again becomes conductive for a single half-cycle of alternating current. By a proper proportioning of the circuit constants, the flow of a single half-cycle of current through the resistor D may be effective to charge the condenser B to a negative potential many times that required to maintain the valve non-conductive. Under these conditions it will require several half-cycles for the capacitor B to discharge to such a potential that the grid of the valve is less negative than its critical grid voltage. By varying the setting of the variable resistor F, both the amount of energy stored in the condenser B during the half cycles in which the valve is conductive and the rate at which this energy is dissipated during the non-conductive half-cycles may be made to vary within wide limits the frequency of the intermittent current supplied to the load device E.—*September 6th*, 1934.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

To-day.

Inst. of British Foundrymen: Junior Section.—College of Technology, Manchester. "Non-ferrous Founding," Mr. C. A. Howe. 7.30 p.m.

Inst. of British Foundrymen: Lancashire Branch.—College of Technology, Sackville-street, Manchester. "Non-ferrous Founding," Mr. C. A. Howe. 6.30 p.m.

Inst. of British Foundrymen: Middlesbrough.—At Cleveland Scientific and Technical Inst., Corporation-road, Middlesbrough. "A Few Notes on Continental Steel Foundry Practice and Castings," Mr. J. G. Wrightson. 7.45 p.m.

Inst. of British Foundrymen: Sheffield.—Grand Hotel, Sheffield. "Suggested Method of Establishing Melting Costs in a Grey Iron Foundry." 7.45 p.m.

Inst. of Electrical Engineers: London Students.—Savoy-place, W.C.2. "Remote Control of Power Stations Using Automatic Type Telephone Switches," Mr. H. M. Yells, 6.30 for 7.15 p.m.

Inst. of Electrical Engineers: Meter and Instrument Section.—Pagani's Restaurant, 42, Great Portland-street, W.1. Annual dinner. 6.45 for 7 p.m.

Inst. of Electrical Engineers: N.-Eastern Students.—Armstrong College, Newcastle-upon-Tyne. "Earthquakes, Sun-spots, and other Disturbances of Radio," Mr. J. F. M. Mellor. 7.15 p.m.

Inst. of Mechanical Engineers.—Storey's-gate, S.W.1. "High-pressure Plant for Experimental Hydrogenation Processes," Mr. A. T. Barber and Mr. A. H. Taylor. 6 p.m.

Inst. of Petroleum Technologists: London Students.—Aldine House, Bedford-street, W.C.2. "The Porosity and Permeability of Rock," Mr. A. B. Cameron. 6.15 p.m.

Inst. of Welding Engineers: N. Western Branch.—Wigan and District Mining and Technology Inst., Wigan. Oxy-acetylene film. 7.15 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. Informal meeting, "High-pressure Boilers with Special Reference to the Simple Tube Type." Mr. J. Calderwood. 7.30 p.m.

N.E. Coast Inst. of Engineers and Shipbuilders.—Mining Inst., Newcastle-upon-Tyne. "The Reduced-speed Running of Merchant Ships," Dr. E. V. Telfer. 6 p.m.

Physical Soc.—Imperial College of Science and Technology, S.W.7. Editing Committee meeting, 3.30 p.m.; Council meeting, 4 p.m.; meeting, 4.45 for 5 p.m.

West of Scotland Iron and Steel Inst.—Royal Technical College, Glasgow. Council meeting, 6.45 p.m.; "Notes on the Open-hearth Basic Process," Dr. J. M. Ferguson, 7.15 p.m.

To-day to Saturday, Nov. 24th.

Machine Tool Exhibition.—Olympia, W. Daily, 10.30 a.m. to 8.30 p.m.; Saturday, 10 a.m. to 10 p.m.

Saturday, Nov. 17th.

Inst. of British Foundrymen: Falkirk Section.—Temperance Café, Lint Riggs, Falkirk. "Some Observations on the Enamelling of Light Castings," Mr. W. A. Shaw. 6 p.m.

Inst. of British Foundrymen: East Midlands.—Technical College, Monks-road, Lincoln. "Suggested Method of Establishing Melting Costs in a Grey Iron Foundry," Mr. C. W. Bigg. 7 p.m.

Inst. of British Foundrymen: East Midlands.—The Technical College, Derby. "Steel Castings," Mr. C. H. Cain. 6 p.m.

Inst. of British Foundrymen: Wales and Monmouth Branch.—Technical College, Newport. "The Engineering Properties of Cast Iron," Dr. A. B. Everest. 6.30 p.m.

Inst. of Electrical Engineers: London Students.—Visit to Hewittic Electric Company, Ltd., and the Hackbridge Electric Construction Company, Ltd., Walton-on-Thames, 2.15 p.m.

Monday, Nov. 19th.

Engineers' German Circle.—At Holborn Restaurant, Holborn, W.C.1. Annual dinner and dance. 7.30 for 8 p.m.

Inst. of Electrical Engineers: S. Midlands.—James Watt Memorial Inst., Birmingham. "Hydro-electric Development in Great Britain, with special reference to the Works of the Grampian Electricity Supply Company," Messrs. S. S. Valentine and E. M. Bergstrom. 7 p.m.

Inst. of Mechanical Engineers: Graduates.—Storey's-gate. S.W.1. "Some Reflections on a Decade of Engineering Experience," Mr. E. J. Fearn. 6.15 for 6.45 p.m.

Liverpool Engineering Soc.—9, The Temple, Dale-street, Liverpool. Monthly luncheon. Address, "Fire Salvage Work," Lieut.-Colonel C. S. Lyon. 1 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. "Modern Spectroscopy," Dr. H. Dingle. 8 p.m.

Wolverhampton and District Engineering Soc.—Victoria Hotel, Wolverhampton. "Machinery and its Relation to Unemployment," Mr. H. E. Partridge. 7.30 p.m.

Tuesday, Nov. 20th.

British Assoc. of Refrigeration.—At Inst. of Marine Engineers, 85/88, Minories, E.C.3. "The Renaissance of the Absorption Machine for Industrial Refrigeration," Dr. G. Maiuri. 6 p.m.

Inst. of Civil Engineers.—Great George-street, S.W.1. Discussion, "The Evolution of Various Types of Crushers for Stone and Ore, and the Characteristics of Rocks as Affecting Abrasion in Crushing Machinery," Messrs. W. T. W. Miller and R. J. Sarjant. 6 p.m.

Inst. of Electrical Engineers: N. Midland Centre.—Hotel Metropole, Leeds, 1. "Developments in Long-distance Telephone Switching," Mr. T. S. Skillman. 7 p.m.

Inst. of Engineers and Shipbuilders in Scotland.—39, Elmbank-crescent, Glasgow. "Trial Performances of a Modern Torpedo Boat Destroyer," Sir Harold Yarrow. 7.30 p.m.

Inst. of Metals: Birmingham Local Section.—James Watt Memorial Inst., Birmingham. "Fatigue in Metals," Dr. H. J. Gough, F.R.S. 7 p.m.

Inst. of Sanitary Engineers.—Caxton Hall, S.W.1. "The Duties and Experiences of a Resident Engineer on Contract Works," Mr. G. Lloyd Ackers. 6 p.m.

Royal Inst. of Great Britain.—21, Albemarle-street, W.1. "The Solid State," Sir William Bragg. 5.15 p.m.

Sheffield Metallurgical Assoc.—198, West-street, Sheffield, 1. "The Properties of Non-hardenable Alpha-iron Steels," Mr. S. H. Rees. 7.30 p.m.

Wednesday, Nov. 21st.

Inst. of Civil Engineers: Students.—Great George-street, S.W.1. Address by Mr. R. R. Tisdale. 6.30 p.m.

Inst. of Locomotive Engineers.—Queen's Hotel, Birmingham. "Modern Tools in Locomotive Shops," Mr. D. H. Keene. 6.45 p.m.

Inst. of Structural Engineers: Scottish Branch.—At 129, Bath-street, Glasgow. "The L.C.C. (General Powers) Act, 1909, for Reinforced Concrete and the Recommended Code of Practice, 1934, in Worked Examples," Mr. W. S. McMillan. 7.15 p.m.

Newcomen Soc.—At Iron and Steel Inst., 28, Victoria-street, S.W.1. Annual general meeting. "Dud Dudley and the Early Coal-Iron Industry," Mr. R. A. Mort. 5.30 p.m.

Royal Microscopical Soc.—B.M.A. House, Tavistock-square, W.C.1. Meeting, 5 for 5.30 p.m.

Soc. of Chemical Industry: Joint Meeting with the Inst. of Plastic Industry.—At Federation of British Industries, 21, Tothill-street, S.W.1. "Urea Plastics," Mr. K. M. Chance. 7.30 p.m.

Thursday, Nov. 22nd.

Inst. of Automobile Engineers.—Red Lion Hotel, Luton. "The Problem of Variable Transmission," Mr. J. Bedford. 7.30 p.m.

Inst. of Civil Engineers: Birmingham and District Assoc.—James Watt Memorial Inst., Birmingham. "The Design of Sewage Treatment Works in the United States of America," Mr. J. T. Calvert. 5.30 for 6 p.m.

Inst. of Electrical Engineers.—Savoy-place, W.C.2. "Generation, Distribution and Use of Electricity on Board Ship," Messrs. C. W. Saunders, H. W. Wilson, and Dr. R. G. Jakeman. 5.30 for 6 p.m.

Inst. of Heating and Ventilating Engineers: London Associate Members and Graduates.—Evening visit to Hovis, Ltd., Grosvenor-road, S.W.1.

Inst. of Structural Engineers.—10, Upper Belgrave-street, S.W.1. "Welding as applied to Structural Steelwork: Recent Developments in Europe," Mr. A. Ramsay Moon. 6.30 p.m.

Royal Aeronautical Soc.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. "Air Turbulence near the Ground," Prof. Dr. Wilhelm Schmidt. 6.30 p.m.

Friday, Nov. 23rd.

Chadwick Public Lectures.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. "Good Housing: The Basis of Individual and Social Health," Sir Raymond Unwin. 5.30 p.m.

Chemical Engineering Group.—Burlington House, W.1. "The Chemical Engineering Aspect of Low-temperature Carbonisation," Colonel W. A. Bristow. 6 p.m.

Inst. of Electrical Engineers: N. Eastern Students' Section.—Tilley's Grand Assembly Rooms, Barras Bridge, Newcastle-upon-Tyne. Annual dance. 8 p.m. to 1 a.m.

Inst. of Mechanical Engineers.—Storey's-gate, S.W.1, Informal meeting. "The Overseas Engineering Representative, His Problems and Difficulties," Mr. B. W. Bagshawe. 7 p.m.

Inst. of Structural Engineers: Midland Counties Branch.—James Watt Memorial Inst., Birmingham. "Cranes," Mr. B. W. Thompson. 6.30 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. "Notes and Hints on the Application of Ball and Roller Bearings," Mr. R. O. Baird. 7.30 p.m.

Manchester Assoc. of Engineers.—Engineers' Club, Manchester. "Lifting Tackle: Its Care and Maintenance," Mr. A. Taylor. 7.15 p.m.

Royal Inst. of Great Britain.—21, Albemarle-street, W.1. Discourse, "Heavy Water in Chemistry," Professor M. Polanyi. 9 p.m.

Stratfordians' Assoc.—Abercorn Rooms, Great Eastern Hotel, Liverpool-street, E.C. Reunion dinner. Particulars from Mr. A. W. Headley, C.M.E. Dept., L.N.E. Railway, Stratford, E.15.

Saturday, Nov. 24th.

Inst. of Mechanical Engineers: London Graduates' Section.—Visit to Beckton Gasworks.

Inst. of Civil Engineers: Students.—Afternoon visit to the reconstruction works, Bank of England.

Monday, Nov. 26th.

Bradford Engineering Soc.—Technical College, Bradford. "The Lubrication of Prime Movers," Mr. A. J. Walker. 7.30 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. Cantor Lecture, "Modern Spectroscopy," Lecture II, Dr. Herbert Dingle. 8 p.m.

Tuesday, Nov. 27th.

Chelsea Polytechnic, S.W.3.—Prize distribution and also diplomas and certificates, by Prof. W. G. Constable. 8.30 p.m.

Inst. of Electrical Engineers: Scottish Centre.—Grosvenor Restaurant, Gordon-street, Glasgow, C.2. Annual dinner; reception, 6.30 for 7 p.m.

Inst. of Electrical Engineers: S. Midland Students.—James Watt Memorial Inst., Birmingham. The Students' Lecture, "Modern Street Lighting," Mr. C. C. Paterson. 7 p.m.

Sheffield Metallurgical Assoc.—198, West-street, Sheffield, 1. "Abnormality as Judged by the McQuaid-Elin Test," Mr. T. Hunter. 7.30 p.m.

Wednesday, Nov. 28th.

Inst. of Automobile Engineers.—Queen's Hotel, Leeds. "The Problem of Variable Transmission," Mr. J. Bedford. 7.15 p.m.

Inst. of Automobile Engineers.—Engineers' Club, Manchester. "The Utilisation Aesthetics of Automobile Body Design," Mr. W. O. Kennington. 7 p.m.

Inst. of Civil Engineers: Yorkshire Assoc.—Grand Hotel, Sheffield. "The Ryburn Dam," Mr. F. L. Pawley. 7.30 p.m.

Inst. of Fuel.—At Chemical Soc., Burlington House, Piccadilly, W.1. "Nature of the Processes of Oil Cracking, Water Gas Carburetting and Hydrogenation," Prof. M. W. Travers, F.R.S. 6 p.m.

Inst. of Welding Engineers: N. Western Branch.—College of Technology, Sackville-street, Manchester. "The Fundamental of Electric Welding," Dr. J. H. Paterson. 7.30 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. "Pottery," Mr. Gordon M. Forsyth. 8 p.m.

Thursday, Nov. 29th.

Inst. of Locomotive Engineers.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "Ejectors," Mr. Conway Arnold. 6 p.m.

Inst. of Metals.—James Watt Memorial Inst., Birmingham. "Directionality in some Annealed Non-ferrous Alloys," Mr. R. G. Johnston. 7 p.m.

Royal Aeronautical Soc.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. "Engine Research," Capt. A. G. Forsyth. 6.30 p.m.

Friday, Nov. 30th.

Inst. of Electrical Engineers: S. Midlands.—Grand Hotel, Birmingham. Annual dinner. 6.30 for 7 p.m.

Inst. of Mechanical Engineers.—Storey's-gate, S.W.1. Thomas Lowe Gray Lecture, "A Survey of Ships and Engines," Mr. Loughnan St. L. Pendred. 6 p.m.

Inst. of Metals: London Local Section.—Thames House, Millbank, S.W.1. Supper-dance. 7.30 p.m. to midnight.

Inst. of Professional Civil Servants.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. Lecture by Mr. A. Keiller. 5 for 5.30 p.m.

LAUNCHES AND TRIAL TRIPS.

Hai Chen, single-screw steamer; built by Barclay, Curle and Co., Ltd.; to the order of the Chinese Government Purchasing Commission for the China Merchants Steam Navigation Company; dimensions, 325ft. by 47ft. by 25ft.; to carry cargo and passengers. Engines, tripe-expansion, 22in., 36in., 60in. by 42in. stroke; constructed by the builders; trial trip, October 31st.

Erratum: River Improvements and Catchment Boards.—At the foot of column 2 of page 442 of our issue of 2nd inst., for "Wey" read "Wye." The fisheries are on the Wye.

Wire Tables.—The London Electric Wire Company and Smiths, Ltd., have issued a revised and improved "Lewcos" Wire Tables. A copy of the new edition will be sent to anyone in the industry on application to the company at Church-road, Leyton, London, E.10. The tables are the most complete with which we are familiar, and are printed in a convenient pocket form.

Structural Steelwork Tables.—A useful pocket-book of lists of steel girders, beams, and pillars has just been issued by Redpath, Brown and Co., Ltd. The tables it contains are compiled from the tables of the British Steel-work Association, amplified by the technical department of the company. The B.S.S. Sections, 1932, are used. The tables cover Beams, Compound Girders, Channels, Joist Pillars, Compound Pillars, and Solid Round Steel Columns.

The Institution of Electrical Engineers: E.H.T. Conference, Paris, Session 1935.—The probable dates for the above session are June 6th to 15th, 1935, and the programme will be divided as follows:—(*a*) Utilisation, interconnection, and protection; (*b*) power station and sub-station equipment; (*c*) construction, insulation, and maintenance of overhead and underground lines. It is desired to bring again to the notice of all interested in the work of the Conference that the British National Committee of the Conference was some years ago set up under the ægis of the Institution of Electrical Engineers to co-ordinate the interests of British engineers, and such co-ordination has become increasingly important in view of the large number of engineers from all over the world who attend the Conference. At the 1933 session there were 751 participants, representing thirty-one countries, a record number in spite of the economic depression then prevailing. It is particularly requested that any British engineer proposing to present a paper coming within the scope of one of the above headings should notify the I.E.E. forthwith, stating the subject of the paper and subsequently submit the MS. through the Institution for transmission to Paris, thus ensuring the desired co-operation with the British National Committee. All communications in regard to papers and attendance at the session should be addressed to the Secretary, the Institution of Electrical Engineers, Savoy-place, London, W.C.2.